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Extinction of Pavlovian conditioned inhibition.

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EXTINCTION OF PAVLOVIAN CONDITIONED INHIBITION

A dissertation Presented

By

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Psychology

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ABSTRACT

Extinction of Pavlovian Conditioned Inhibition

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Experiments 1 and 2 investigated the use of nonreinforced presentations of inhibitory and excitatory stimuli in an attempt to attenuate the inhibition established through a simultaneous compound conditioned inhibition training procedure. Experiment 1, using a conditioned inhibition savings test for inhibition, revealed no decrement in inhibition following nonreinforced presentations of the inhibitory stimulus (X), the excitatory stimulus (A), and the inhibitory-excitatory compound (AX). In contrast, Experiment 2, using a summation test of inhibition, showed a decrement in inhibition in both a group receiving such experience with nonreinforced stimuli and a group which received no such experience but which did experience a "forgetting" interval between training and testing.

Experiment 3 followed up the results of Experiment 2 with an investigation of the effects of a retention interval on inhibition. It was found that a 30-day interval, spent by experimental animals in their cages, produced a definite, but short-lived, decrement in inhibition. On the basis of the above three experiments, it was concluded that the nonreinforced presentations of the inhibitory stimulus following simultaneous compound conditioned inhibition training was not effective in attenuating inhibition -- although it might be effective in other cases -- and that retention of conditioned inhibition was subject to disruption,

if temporary, with the passage of time.

Experiment 4 investigated the presentation of an inhibitory stimulus in a noncorrelated manner (truly random) with shock in an attempt to extinguish inhibition established through simultaneous compound conditioned inhibition training. It was found that such a procedure (which degraded the negative correlation between the inhibitory stimulus and shock) was successful in quickly and permanently weakening inhibition.

The implications of the results for current models of classical conditioning were discussed.

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Pavlov (1927) demonstrated that, just as a neutral stimulus can acquire excitatory properties by way of its association with reinforcement, so too can a stimulus acquire inhibitory properties by way of its association with nonreinforcement. Most recent conceptions of conditioned inhibition have characterized inhibition as an antagonist to excitation. That is, inhibition is defined as the learned ability of a stimulus "to control a tendency directly opposite to that of a conditioned excitor" (Rescorla, 1969b, p. 92). Accordingly, conditioned inhibition is generally assessed empirically in terms of the ability of the conditioned inhibitor to oppose excitatory tendencies. This is typically accomplished by using one or both of the following procedures: 1) A summation test procedure, in which the supposed inhibitor is presented in nonreinforced compound with a known excitatory CS in order to assess the ability of the inhibitor to disrupt (or oppose) excitation; or 2) A retardation test procedure, in which a supposed inhibitor is paired with reinforcement in order to assess the ability of the inhibitory CS to resist excitatory conditioning (Rescorla, 1969b). A third technique, the conditioned inhibition savings test, measures the ease with which a simultaneous compound conditioned inhibition training procedure establishes an A+, AX- discrimination, the assumption being that the control of inhibitory tendencies by X prior to discrimination training will facilitate the discrimination (Wagner & Rescorla, 1972).

The conditions under which Pavlovian conditioned inhibition is established have been reviewed by Rescorla (1969b). These include: 1) A simultaneous compound conditioned inhibition procedure, in which one stimulus (A), presented alone, is always reinforced, while a compound (AX)

of the stimulus and a second stimulus (X) is nonreinforced (Pavlov, 1927); 2) A negative CS-US contingency procedure, in which a negative correlation between a CS (X) and reinforcement is arranged such that the probability of reinforcement is greater in CS absence than in CS presence (Baker, 1977; Hammond & Daniel, 1970; Rescorla, 1969a; Witcher, 1974); 3) A differential conditioning procedure, in which one stimulus (A) is always reinforced, while a second stimulus (X) is never reinforced (Hammond, 1966; 1967); 4) A long-delay CS procedure, in which an extended CS comes to control a temporal pattern of responding such that an excitatory pattern of responding is established during the later portion of the CS, while an opposite, or inhibitory, tendency is observed early in the CS interval (Rescorla, 1967a); or 5) A backward conditioning procedure, in which a stimulus is associated with the termination of shock (and a shock-free period)(Moscovitch & LoLordo, 1968).

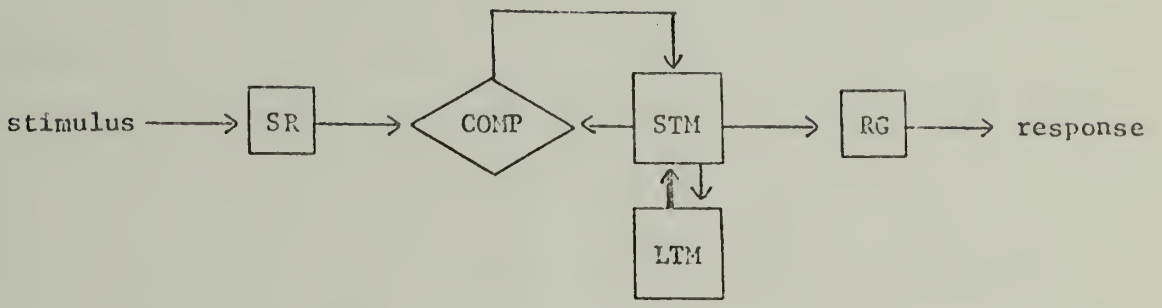
Each of these procedures can be viewed as a variation on the first, simultaneous compound conditioned inhibition paradigm, A+, AX-. In procedures 2, 3, and 5, however, the excitatory A cue is a background or apparatus cue which has been paired with a US; while in procedure 4, the inhibitory cue is temporal. Each establishes inhibitory tendencies by way of an association with nonreinforcement. While Pavlov (1927) studied conditioned inhibition based on salivary conditioning in dogs, the majority of recent studies involve conditioned inhibition based on a shock US. These studies include: 1) The transfer of inhibitory control to reduce responding in free operant avoidance situations (in rats, Grossen & Bolles, 1968; in dogs, Rescorla & LoLordo, 1965); 2) The rabbit's nictitating membrane response (Marchant, Mis & Moore, 1972; Siegel &

Domjan, 1971); 3) The CER procedure with rats (Hammond, 1966; 1967). In addition, the development of conditioned inhibition has been reported in the taste-aversion learning situation, where the US is toxicosis (Best, 1975; Taukulis & Revusky, 1975).

It has been suggested that "learning occurs when outcomes violate the organism's expectations" (Rescorla, 1973) or when the outcome is "surprising" (Wagner & Rescorla, 1972). On any given trial, prior experience (if any) with the stimuli present on that trial will lead the organism to "expect" (to a greater or lesser degree) the outcome of that trial. To the extent that the organism's expectations are discrepant from the actual outcome, the organism engages in "mental work" concerning the event (Kamin, 1969). This mental work is seen as a prerequisite for learning. Thus, on a given conditioning trial, "it is the discrepancy itself that is the reinforcer" (Rescorla, 1969c, p.86) by way of its ability to provoke mental processing.

In the language of information processing models, predictions about events are made on the basis of information, placed into a temporary Short-Term Store (STS), about immediate and recalled experience. In the latter case, any stimulus present on a given trial will act as a cue to recall from a permanent Long-Term Store (LTS) information associated with it as a function of previous learning. Discrepancies between predictions about events and the subsequent events provoke a rehearsal process which maintains the information in STS, thus facilitating transfer to LTS (Atkinson & Wickens, 1971; Wagner, 1976).

The process described above is represented in the following diagram (Pfautz & Wagner, 1976):



Information about current events enters the processing system via the sensory register (SR). This information is then read by a comparator (COMP), which also receives information from short-term memory (STM or STS). The information in STM may represent the immediate past, maintained in STM by rehearsal, or a more distant past, recalled to STM from long-term memory (LTM or LTS) by external stimuli.

The COMP transfers information from SR to STM (for rehearsal and possible transfer to LTM) only if that information is discrepant from the current contents of STM. The prerepresenting, or "priming," of a stimulus in STM, either by prior presentation of the stimulus and/or by recall of the stimulus from LTM by other cues, reduces its effectiveness on subsequent presentations (Pfautz & Wagner, 1976; Wagner, 1976). The presentation of a US will provoke little mental work if it is preceded by a CS which, as a result of previous CS-US pairings, has become strongly associated with the US. This CS presentation will cause the associated US representation in LTM to be transferred to STM and subsequent US presentations will be less likely to be transferred to STM by COMP. For

example, the US will be less effective when reinforcing a neutral cue when that cue is presented in compound with a CS already associated with the occurrence of the US (Kamin, 1968). On the other hand, an unexpected event should be especially effective in commanding mental work (Terry & Wagner, 1976; Wagner, Rudy & Whitlow, 1973) and especially effective as a reinforcer, as, for example, when a neutral cue is reinforced in compound with a CS already associated with the absence of reinforcement (Rescorla, 1971).

Two important points follow from the basic idea that surprising events provoke learning. First, all stimuli present on a trial contribute to the expectations of the organism on that trial, so that concurrent stimuli play an important role in the determination of how much mental work is accorded to a stimulus presented in compound with them. Second, each experience with a stimulus and an outcome reduces the discrepancy between expectations and outcomes, and thus reduces the likelihood that mental work will take place, to the point where an asymptote is reached where expectations match outcomes (Atkinson & Wickens, 1971; Wagner & Rescorla, 1972).

Conditioned inhibition develops when there is a negative discrepancy between the organism's expectations about reinforcement and the actual outcome of a trial, as, for example, when the organism expects a US and no US occurs. This is precisely the case in conditioned inhibition training of the form A+, AX-. Reinforced A trials lead the subject to expect reinforcement on AX trials. However, AX trials are not reinforced and so the subject is "surprised" and inhibition is conditioned to X. Similarly, the occurrence of reinforcement in the presence of

background cues (A), as, for example, in the negative contingency procedure, leads the subject to expect the US on CS (X) trials because of the presence of background cues. The subject is "surprised" when no reinforcement occurs and therefore the CS becomes inhibitory.

Rescorla and Wagner (1972) have suggested that learning, or changes in the "surprisingness" or associative strength of a stimulus on a given conditioning trial can be quantitatively represented by the equation:

$$\Delta V_i = \alpha_i \beta (\lambda - \bar{V}) \qquad (1)$$

where V_i = the associative strength of stimulus i

α_i = a learning rate parameter, dependent upon the nature of i (e.g., its salience)

β = a learning rate parameter, dependent upon the properties of the US (e.g., its intensity)

λ = the asymptotic level of conditioning which the US will support

$\bar{V}$ = the total associative strength of all stimuli present on a given trial (e.g., stimulus i plus background cues)

Obviously, the greater the discrepancy between λ and $\bar{V}$, the greater the change in V_i.

In the above formulation, inhibition resulting from a negative discrepancy is represented by a negative V-value. Assuming that the asymptote of conditioning (λ) associated with nonreinforcement (or zero US intensity) is zero (Wagner & Rescorla, 1972), a positive $\bar{V}$ will lead to a change in V_i which is in a negative, or inhibitory, direction. A stimulus must be nonreinforced, therefore, in the presence of other stimuli which have positive associative strength, thus making $\bar{V}$ positive and the quantity ($\lambda - \bar{V}$) negative. For example, in the simultaneous

compound conditioned inhibition procedure, changes in the associative strength of X and A are defined by the following variations of Equation 1:

on reinforced A trials:

$$\Delta V_A = \alpha_A \beta (\lambda - V_A) \tag{2}$$

on nonreinforced AX trials:

$$\Delta V_A = \alpha_A \beta (0 - (V_A + V_X)) \tag{3}$$

$$\Delta V_X = \alpha_X \beta (0 - (V_A + V_X)) \tag{4}$$

On reinforced A trials, V_A is increased (i.e., V_A becomes positive). Nonreinforced AX trials result in decrements in V_A and V_X (for the quantity $(V_A + V_X)$ is positive). While V_A continues to be positive, maintained by reinforced A trials, V_X becomes negative. As A becomes excitatory, X becomes inhibitory.

While a great deal is known about the procedures leading to the development of conditioned inhibition, relatively little is known about the procedures which lead to a decrement in or the extinction of conditioned inhibition. Pavlov (1927) suggested that:

> it is obvious that a complete abolition of the inhibitory properties of the [stimulus] combination should most readily be brought about by reversing the technique employed in its formation - i.e., by systematically reinforcing the inhibitory combination by the appropriate unconditioned reflex (p. 81).

Pavlov (1927) demonstrated that, following conditioned inhibition training, in which an A stimulus was reinforced while an AX compound was not reinforced, subsequent reinforcement of the AX compound indeed eliminated the inhibitory properties of the X element. This procedure is essentially identical to the retardation test procedure, which was previously mentioned in connection with the measurement of conditioned inhibition.

More recently it has been suggested that "the most straightforward way in which loss of inhibition should be accomplished is simply nonreinforced presentations of the stimulus" (Wagner & Rescorla, 1972). This procedure corresponds with that typically employed to extinguish excitatory conditioning. Within the framework of the Rescorla-Wagner model of conditioning, loss of inhibition is predicted from repeated nonreinforced presentations of the inhibitory CS. An inhibitory CS (X) will have a negative associative strength. On nonreinforced X trials, changes in V_X will be defined by the equation:

$$\Delta V_X = \alpha_X \beta (0 - \bar{V}) \tag{5}$$

If the quantity $(0 - \bar{V})$ is positive (i.e., if $\bar{V}$ is negative), then V_X will be incremented toward zero; and inhibition should be attenuated. Positively conditioned stimuli occurring in compound with X (e.g., background cues) may retard the extinction of inhibition in X by keeping the quantity $(0 - \bar{V})$ negative. However, the positive associative strength of these cues should decrease in the presence of nonreinforcement, allowing V_X to approach zero.

Some indirect empirical data suggest that the prediction of extinction of inhibition through nonreinforced presentations of the inhibitory CS may not be valid. Rescorla and LoLordo (1965) studied the effects of a Pavlovian CS- for shock (i.e. a conditioned inhibitor) upon instrumental behavior. Superimposing the CS- on avoidance responding (during extinction of the avoidance baseline), the experimenters found that the stimulus suppressed responding. Moreover, the stimulus continued to be effective in suppressing avoidance behavior despite repeated nonreinforced presentations (albeit on a background which may have been excitatory).

Further, Badia and Culbertson (1972), in an experiment designed to study the aversiveness of signalled versus unsignalled shock, gave rats the opportunity to switch, by way of a bar-press response, from a condition in which inescapable shock was not signalled to a condition in which each inescapable shock was reliably predicted by a 5-sec signal (A). A bar-press response produced a "correlated" stimulus (X) which lasted for 3 minutes, during which time each inescapable shock was preceded by A. At the end of the period, X was terminated and Ss returned to the unsignalled condition, which could be terminated again by a bar press. The rats came to bar press at a rate sufficient to maintain the signalled condition (and the X stimulus) for most of the experimental session. This procedure can be analysed in terms of a differential conditioning procedure. In the signalled condition, the compound (AX) of the correlated stimulus and the signal for shock was always predictive of shock, while X alone was associated with a period free of shock. That is, AX corresponds to a CS+ for shock, while X acts as a CS- for shock. Of

interest here is the fact that during an extinction phase of the experiment, in which each bar press continued to produce X but not the signalled condition (i.e., inescapable shocks occurring during the 3-min X stimulus were no longer signalled by A), the rats continued to bar press. Note that X was no longer discriminative of a shock-free period and, in fact, was occasionally paired with shock. If the ability of X to maintain responding was based on conditioned inhibitory properties acquired through an association with the absence of reinforcement, then these data suggest that inhibition is resistant to extinction even though the inhibitory stimulus is subsequently paired with shock.

A recent study (Zimmer-Hart & Rescorla, 1974) was explicitly directed toward defining the conditions under which conditioned inhibition might be extinguished. The authors approached the extinction of inhibition from two directions: 1) by repeatedly presenting the conditioned inhibitor without reinforcement, and 2) by removing the correlation between the conditioned inhibitor and reinforcement, i.e., by destroying its informational value with respect to nonreinforcement.

In the initial experiment, rats received simultaneous compound conditioned inhibition training (A+, AX-). Reinforcement was a .5-sec, .8-mA shock. This procedure was designed to establish X as a conditioned inhibitor. Subsequently, half of the rats received 96 nonreinforced presentations of the X cue over 4 days of extinction, while the other half, acting as a control for the passage of time, were exposed to the apparatus cues only. Finally, the degree of inhibition controlled by X was assessed in terms of a summation procedure (i.e., A-, AX- trials). Conditioned effects were measured in terms of changes in the ongoing

rates of bar pressing for food reinforcement in the presence of the CSs. Presentations of an excitatory CS should suppress responding, while the addition of an inhibitory cue should attenuate suppression. To the degree that the inhibition controlled by X had been extinguished through nonreinforced presentations, the ability of X on AX trials to attenuate the excitation controlled by A should be less, compared to that of the control group. The results were, however, that X continued to attenuate A's excitatory power equally in both groups.

This initial experiment, then, suggested that nonreinforced exposure to a conditioned inhibitor does not lead to the extinction of inhibition. In a second experiment, Zimmer-Hart and Rescorla used a, presumably, more sensitive within-subject design. Subjects experienced treatments designed to establish two stimuli (X and Y) as conditioned inhibitors through A+, AX-, AY- trials. Subsequently, the rats received 72 nonreinforced presentations, over 6 days, of only one of the inhibitory stimuli (e.g., X). The other inhibitor was not presented during that time. This procedure was designed to attenuate the inhibitory power of X while leaving that of the other (Y) intact. Testing consisted of a summation procedure. Suppression of bar pressing during nonreinforced A, AX, and AY trials was measured. If X had lost inhibition through nonreinforced presentations, it should be less effective, relative to Y, in attenuating suppression to A. The results were, however, that, following experimental treatment, both X and Y continued to attenuate suppression equally to A.

Failing to confirm the prediction of the Rescorla-Wagner model that conditioned inhibition should be extinguished by nonreinforced presentations of the inhibitory CS, Zimmer-Hart and Rescorla attempted to extin-

guish inhibition by removing the negative correlation between the inhibitor and the US. Initially, inhibition was established through simultaneous compound conditioned inhibition training (A+, AX-). Following this, two groups of Ss were exposed to four A and four AX trials for 8 sessions under conditions designed to eliminate the association between X and nonreinforcement. In one group (Group S), both A and AX trials were reinforced; in a second group (Group NS), neither A nor AX trials were reinforced. A third group (Group BP), was exposed to the apparatus cues only. Immediately following this, all Ss received reinforced A trials, in order to equate them in terms of suppression to A (which had been extinguished in Group NS).

Finally, the inhibitory strength of X was tested in a summation procedure. Subjects received six nonreinforced presentations of both A and AX over 3 test days. Only Group S, which had experienced reinforced A and AX trials, showed a loss of inhibition. For Group NS, which had experienced nonreinforced A and AX trials, X continued to weaken suppression on AX trials, as it did for Group BP. Thus, even though the correlation between X and nonreinforcement had been removed in Group NS, X remained inhibitory. Only when both AX and A trials were reinforced was inhibition attenuated.

The following experiments investigated further the conditions under which conditioned inhibition is attenuated. Essentially, they involved variations of the two approaches used by Zimmer-Hart and Rescorla (1974): the extinction of inhibition by 1)nonreinforced presentations of the inhibitory CS, and 2)removal of the CS-US correlation.

Experiment 1

Experiment 1 tested further the prediction that nonreinforced presentations of a conditioned inhibitor should reduce its inhibitory power. It differed from similar experiments by Zimmer-Hart and Rescorla (1974) in that, following simultaneous compound conditioned inhibition training, subjects were exposed to nonreinforced X trials and to nonreinforced A and AX trials. The intuitive appeal of this design is as follows: In the theoretical approaches to conditioned inhibition discussed above, the development of inhibition by a CS is dependent upon the prior development of excitation to a second CS with which the inhibitory CS is presented in a nonreinforced compound. Perhaps, then, the extinction of excitation may likewise be necessary for the extinction of inhibition.

It should be noted, however, that in the Rescorla-Wagner model, the extinction of inhibition following simultaneous compound conditioned inhibition training does not require the extinction of excitation to the A cue. Nonreinforced presentations of the inhibitor alone should be sufficient to degrade inhibition. In fact, in terms of Equation 5, which defines changes in V_X on nonreinforced X trials, the associative strength of A (V_A) plays no role.

While the associative strength of A should not, according to the Rescorla-Wagner model, affect V_X during extinction, mediation by the background cues (B) cannot be ruled out. In fact, Equation 5 should, to completely describe conditioning effects, read:

$$\Delta V_X = \alpha_X \beta (0 - (V_X + V_B)) \qquad (6)$$

where V_B represents the conditioned effects of the background cues. During conditioned inhibition training, the background cues gain positive associative strength by way of reinforcement in compound with the A cue. Presumably, this gain is balanced by a loss on nonreinforced AX and B-alone trials. To the extent, however, that the background stimuli remain excitatory, X may be protected from extinction through nonreinforcement (Wagner & Rescorla, 1972).

In the present experiment, nonreinforced A, AX, and X trials continued until the subjects no longer showed suppression of bar pressing in the presence of A. The data should indicate that A and, presumably, B no longer control excitatory tendencies. The possibility, then, that excitatory background cues are maintaining inhibition in X despite nonreinforced X trials becomes less likely. In addition, nonreinforced AX trials should contribute to a decrement in the inhibitory strength of X according to the Rescorla-Wagner model.

The similarity of this procedure to that of the last experiment in Zimmer-Hart and Rescorla (1974), in which the CS-US correlation was removed by presenting nonreinforced A and AX trials, should be noted. Zimmer-Hart and Rescorla found that such a procedure did not lead to the extinction of inhibition. However, the present study differed from that study in a potentially significant fashion. In Zimmer-Hart and Rescorla, the noncorrelated procedure was followed by retraining to A (i.e., A+ trials). In terms of the intuitive notion discussed above, the reestablishment of A's excitatory properties may have restored X's inhibitory powers, even though those inhibitory powers may have been weakened previously by nonreinforced presentations.

That inhibitory connections may continue to exist between X and reinforcement despite a weakening of X's measured inhibitory properties is suggested by a recent study (Rescorla & Heth, 1975) in which an extinguished CS-CR connection was presumably reactivated by US presentations following extinction. That is, a CS previously positively correlated with reinforcement was extinguished through repeated nonreinforced presentations, such that the CS no longer evoked a CR. Subsequently, US-alone presentations were able to restore the conditioned properties of the CS (i.e., the CS again evoked a CR).

Rescorla and Heth (1975) suggest that, in conditioning, an organism develops 1) memory images about stimulus events, and 2) associative connections between CS and US images, and that changes in performance in the presence of the CS may represent changes in either one of these. For example, in the extinction of excitation, the subject may fail to respond in the presence of the CS either because 1) the image of the US has been reduced in strength through pairings of the CS with a low (zero) intensity US, or 2) the connections between the CS and the US image, which allow the CS to evoke a CR, are weakened because the US no longer follows the CS. The reinstatement of responding following extinction by US presentations suggests that both of these things may indeed be happening during extinction. Presentations of the US following extinction may strengthen the US memory image, so that the CS may evoke a portion of the CR by way of still existing CS-US associative connections.

In terms of conditioned inhibition, the image of "not-US' evoked by the presentation of the conditioned inhibitor may be maintained by the image of "US" associated with the excitatory CS which participates in the

development of conditioned inhibition. The retraining of A in Zimmer-Hart and Rescorla (1974) may have reinstated the "US" image and thus the inhibition controlled by X. If this were the case, any changes in the response to X following nonreinforced A and AX trials might fail to show up during testing. For these reasons, in the present experiment the strength of X's inhibitory control will be tested using a conditioned inhibition savings test (i.e., in terms of the ease with which X acquires inhibitory properties based on a second excitatory CS (B)). This eliminates the necessity for retraining A. Of interest will be the rate of acquisition of conditioned inhibition in a group of animals exposed to nonreinforced A, AX, and X trials following simultaneous compound conditioned inhibition training, relative to a group receiving similar conditioned inhibition training but no subsequent exposure to nonreinforced stimuli. If nonreinforced presentations of A, AX, and X stimuli do, in fact, attenuate the inhibitory properties of X, then subsequent simultaneous compound conditioned inhibition training with a new excitatory CS should be retarded in subjects receiving such experience relative to those who do not.

Method

Subjects

Sixteen Holtzman male albino rats 95-105 days old at the start of the experiment were housed individually and maintained on a 22-hr water deprivation schedule, while food was freely available.

Apparatus

Eight Gerbrands operant conditioning chambers with left-side dipper feeders and centrally mounted levers were housed in .61-m cubes of 13-mm plywood lined with acoutical tile. A 1,000-Hz, 84-dB tone (re 20$\mu N/m^2$) presented through a 10-cm speaker mounted on the lid of the chamber served as the initial excitatory stimulus (A). A 87-dB white noise (re 20$\mu N/m^2$), presented through a second adjacent speaker served as an excitatory stimulus in the testing phase of the experiment. The inhibitory stimulus (X), a 1/sec flashing light, was created by changing the illumination provided by two cue lights, in synchrony, from 6.5 V to 26 V on a 1/sec pulse. Scrambled grid shock USs were provided by Grason-Stadler shock sources (Models E1064GS and 700). The baseline response to be affected by CS presentations was bar pressing, reinforced with 4-sec presentations of a .1-ml dipper cup containing water.

Procedure

Preliminary training. Rats were water deprived for 48 hr, then in one initial session, lasting up to 2 hr, were shaped to bar press on CRF for water reinforcement. Animals met criterion when they made 50 responses in this period. At the end of this first session, and each following session, Ss were given access to water in their home cages for 5 min only. Five daily 2-hr sessions followed with a VI 1-min schedule of reinforcement in effect.

The following conditioning phases of the experiment are summarized in Table 1a.

Table 1: Types of stimulus events scheduled during various stages of conditioning. Plus signs (+) indicate reinforcement; minus signs (-) indicate nonreinforcement; asterisks (*) indicate truly random CS-US presentations.

Table 1a: Experiment 1

Group	Simultaneous compound conditioned inhibition	Extinction	Conditioned inhibition savings test
E	A+, AX-	A-, AX-, X-	B+, BX-
C	A+, AX-	bar press	B+, BX-

A=tone, X=light, B=noise, US=.5-sec, .8-mA shock

Table 1b: Experiment 2

Group	Test stimulus training	Simultaneous compound conditioned inhibition	Test reminder	BAR PRESS	Extinction	Summation test	Retardation test
E	B+	A+; A+, AX-	B+		A-, AX-, X-	B-, BX-	X+
C	B+	A+; A+, AX-	B+		bar press	B-, BX-	X+

A=noise, X=tone, B=light, US=1-sec, 1-mA shock

Table 1: (continued)

Table 1c: Experiment 3

Group	Simultaneous compound conditioned inhibition			Summation test	Retardation test
C	A+;	A+, AX-	BAR PRESS	A-, AX-	X+
F	A+;	A+, AX-	"FORGETTING" BAR PRESS	A-, AX-	X+

A=tone, X=light, US=1-sec, 1-mA shock

Table 1d: Experiment 4

Group	Simultaneous compound conditioned inhibition		Extinction		Summation test	Retardation test
E	A+;	A+, AX-, AY-	A+,X*,AX-(AY-)	BAR PRESS	A-,AX-,AY-	X+, Y+
N	A+;	A+	A+,X*,AX-(AY-)	BAR PRESS	A-,AX-,AY-	X+, Y+

A=noise, X=light (Grps. E-L, N-L) or tone (Grps. E-T, N-T), Y=light (Grps. E-T, N-T) or tone (Grps. E-L, N-L), US=1-sec, 1-mA shock

Simultaneous compound conditioned inhibition training. This phase was designed to establish a tone CS (A) as a conditioned excitor and a flashing light CS (X) as a conditioned inhibitor. All Ss experienced six reinforced presentations of the A stimulus and six nonreinforced presentations of the X stimulus delivered coterminously with A (AX). The A and AX stimuli were presented randomly in time with the requirement that they not overlap and that each block of two trials contain one A and one AX presentation. All stimuli were 2 min long; the reinforcement was a .5-sec, .8-mA shock which began with CS termination. This treatment continued for a total of 11 sessions.

Throughout conditioned inhibition training, Ss continued to bar press and receive water reinforcement on a VI 1-min schedule. Response rates were monitored throughout training sessions and all subsequent sessions. The effects of stimulus presentations were assessed in terms of the amount of suppression of bar pressing during the stimulus. Suppression was measured by forming a ratio of response rates of the form $A/(A+B)$, where A is the response rate during a 2-min CS and B is the response rate during the 2-min period immediately preceding the CS (Annau & Kamin, 1961). A ratio of 0 indicates complete suppression to the CS (i.e., excitatory conditioning) while a ratio of .50 suggests that the CS has no effect upon responding.

Extinction of excitation and inhibition. For the next six sessions, Ss were divided into two groups of eight animals each. Group C (a forgetting control) continued to bar press for water reinforcement on a VI 1-min schedule, experiencing no stimulus events of any kind. A second group, Group E, received in each 2-hr session four nonreinforced presen-

tations each of the A, AX, and X stimuli superimposed on bar pressing. These trials were designed to attenuate the inhibition controlled by X. This extinction phase continued for 6 days in all, at the end of which Ss were no longer suppressing in the presence of A. It was presumed that by this time there would be little or no excitation remaining conditioned to A or to the background cues, and, more importantly, no inhibition remaining conditioned to X.

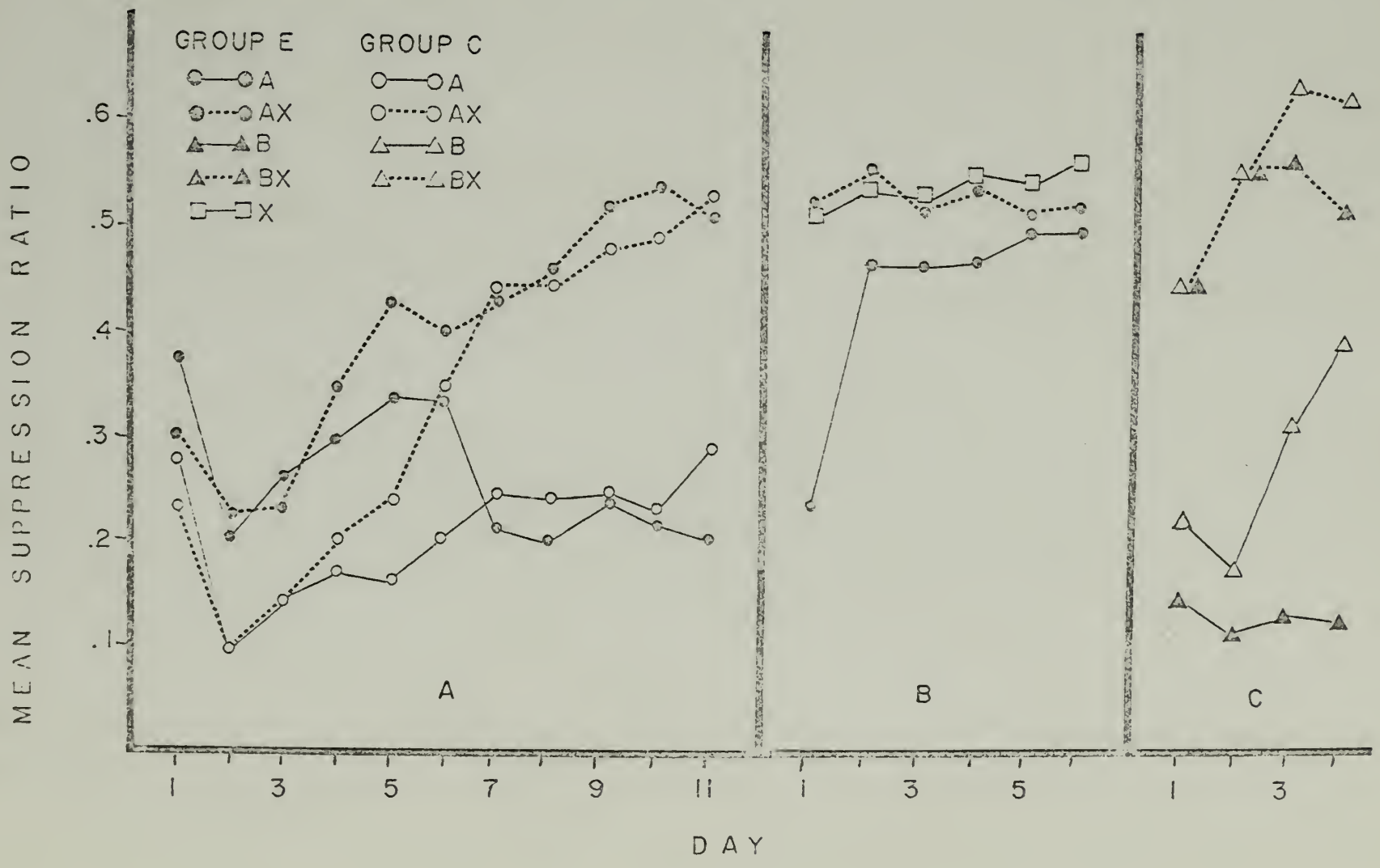
Conditioned inhibition savings test. In this phase, all Ss received simultaneous compound conditioned inhibition training similar to initial conditioned inhibition training except that a white noise stimulus (B) was substituted for the A stimulus of earlier training. In four daily 2-hr sessions, Ss received six reinforced presentations of an 87-dB white noise (B) and six nonreinforced presentations of the flashing light stimulus delivered coterminously with the B stimulus (BX). All stimuli were 2 min in duration; reinforcement was a .5-sec, .8-mA shock. Again, Ss continued to bar press during testing; and stimulus effects were measured in terms of suppression ratios.

Results

The results of Experiment 1 are presented in Figure 1 in terms of the mean group suppression ratios associated with: 1) reinforced A and nonreinforced AX trials during initial simultaneous compound conditioned inhibition training for Groups E and C (Panel A); 2) nonreinforced A, AX, and X trials during extinction for Group E (Panel B); and, 3) reinforced B and nonreinforced BX trials during the conditioned inhibition savings test for Groups E and C (Panel C).

FACE PAGE FOR FIGURE 1

Figure 1: Mean suppression ratios for Groups E and C in Experiment 1
Panel A: Simultaneous compound conditioned inhibition training
Panel B: Extinction (Group E only)
Panel C: Conditioned inhibition savings test


GROUP E
A
AX
B
BX
X
GROUP C
A
AX
B
BX
MEAN SUPPRESSION RATIO
.6
.5
.4
.3
.2
.1
A
B
C
1
3
5
7
9
11
1
3
5
1
3
DAY

During initial conditioned inhibition training (Panel A), Groups E and C learned to discriminate between A and AX at similar rates. At the end of training, Ss in both groups suppressed during (reinforced) A presentations and did not suppress during (nonreinforced) AX presentations. There were no significant differences between the two groups during this phase of the experiment ($t=.35$, $df=14$, $p>.70$, two-tailed).

During extinction (Panel B), nonreinforced AX trials continued to have no apparent effect upon bar pressing, while A trials rapidly lost their ability to suppress responding. Presentations of the X stimulus also had little effect upon responding. By the end of extinction, there were no significant differences in the effects of the three stimuli upon responding ($ts<2.05$, $df=7$, $ps>.05$, two-tailed).

During conditioned inhibition savings testing (Panel C), no significant differences between Groups E and C were found. Indeed, both groups showed a strong differentiation between B and BX trials on the first day of testing. Because transfer was so immediate, efforts to find differences between the two groups were concentrated on the early trials on Day 1 of testing. Table 2 indicates group suppression ratios on the twelve stimulus trials on Day 1 in the order in which the stimuli were presented. It can be seen that, in both groups, Ss responded similarly on the first BX and B presentations; by the second time the BX and B cues were presented, B suppressed responding while X attenuated suppression when compounded with B. This trend, of increasing suppression to B accompanied by increased attenuation of suppression on BX trials, continued in a similar fashion for both groups on Day 1, although Group C appeared to develop somewhat weaker suppression to B than did Group E.

Table 2: Experiment 1. Mean group suppression ratios on each B and BX trial on Day 1 of conditioned inhibition savings testing (in the order in which they occurred).

	Trial											
Group	BX	B	B	BX	B	BX	BX	B	BX	B	B	BX
E	.39	.38	.14	.39	.11	.43	.49	.07	.52	.07	.12	.47
C	.32	.30	.22	.44	.18	.50	.48	.30	.48	.20	.20	.48

T-tests based on difference scores (i.e., suppression ratios during B minus suppression ratios during BX) for this first day of testing and for the 4 days of testing overall revealed no significant differences between the two groups ($ts < 1.67$, $df=14$, $ps > .05$, one-tailed).

Discussion

The main finding of this study is that the nonreinforced presentations of A, AX, and X trials following simultaneous compound conditioned inhibition training failed to extinguish the inhibitory properties of X. Following extinction training, Group E acquired a B+, BX- discrimination equally as fast as did Group C. This result supports the findings of Zimmer-Hart and Rescorla (1974), even though, in the present study, no reinforced A trials were interpolated between extinction and testing for inhibition.

It remains possible that the inhibitory CS was protected from extinction despite the procedural modifications included in Experiment 1. Perhaps, for example, the background cues were not neutral during extinction and, if excitatory, were able to support the inhibitory properties of X. More importantly, while Ss in Group E did not experience shock in conjunction with the A stimulus subsequent to the end of simultaneous compound conditioned inhibition training, they nevertheless did experience the same US in conjunction with the training of B during the conditioned inhibition savings test. If A+ training might reinstate a "US image", so too might any experience with the same US. The following experiment was designed to handle these problems.

Experiment 2

Like Experiment 1, Experiment 2 involved the establishment of conditioned inhibition through a simultaneous compound conditioned inhibition training procedure followed by an experimental treatment involving nonreinforced presentations of A, AX, and X stimuli. The significant procedural changes introduced in Experiment 2 were as follows:

1) A summation procedure (followed for completeness by a retardation test) was used to assess the inhibitory control of X following the extinction procedure. This test involved nonreinforced presentations of an excitatory CS (B) alone and in compound with X. The excitatory B stimulus was conditioned prior to simultaneous compound conditioned inhibition training. These changes insured that a shock US was not experienced after the extinction phase of the experiment had begun and until testing had taken place.

2) To insure further that excitatory background cues were not supporting the inhibitory properties of X during extinction, operant recovery sessions were interpolated between simultaneous compound conditioned inhibition training and extinction. During this time, Ss experienced neither stimuli nor shocks while bar pressing for reinforcement.

3) The nature of the A, B, and X stimuli were changed somewhat. First, they were shortened from 2-min to 1-min duration in order to minimize the development of bar pressing during a CS due to inhibition of delay. Second, in order to minimize possible generalization between A and B (in Experiment 1 they were both auditory stimuli), A became a white noise, B a flashing light, and X an intermittent tone. The expectation

was that the A (noise), AX (noise-tone) discrimination would be difficult to develop; therefore the reinforcer associated with A was increased to a 1-sec, 1-mA shock in order to facilitate the development of inhibition to X (Rescorla & Wagner, 1972). The discrimination did, in fact, prove to be a difficult one.

Method

Subjects and Apparatus

Subjects were 16 Holtzman male albino rats similar to those of Experiment 1. In this experiment,however, Ss were food deprived and maintained at 80% of their free feeding weight.

Bar pressing was reinforced with a 4-sec presentation of a .1-ml dipper cup containing a 32% (w/w) sucrose solution. This departure from Experiment 1 was designed to create a more robust level of baseline bar pressing.

The apparatus was unchanged, but the stimuli differed somewhat from those employed in Experiment 1. Here, a 1/sec flashing light, created by changing the illumination provided by two lights in synchrony from 26 V to 6.5 V, served as the excitatory CS (B) to be used in summation testing. A 75-dB white noise served as the initial excitatory CS (A).* Finally, the inhibitory stimulus (X) was an intermittent 1,000-Hz, 84-dB tone. A 1-sec, 1-mA scrambled shock served as a US. All CSs were 1 min in duration.

*On Day 38 of conditioned inhibition training, the white noise level was decreased to 73 dB, and on Day 39 to 71 dB to facilitate training -- i.e., by making the tone more salient relative to the noise.

Procedure

Preliminary training. In a single 1-hr magazine training session, the bars were removed from the operant chambers, and 4-sec presentations of sucrose were delivered to Ss on a VT 1-min schedule. On the following day, the bars were replaced, and sucrose reinforcement was made contingent on each bar press. Ss were required to make 50 responses in this session and were shaped if necessary. Five daily 2-hr sessions followed with a VI 2-min schedule of reinforcement in effect. In the initial session, however, reinforcement was delivered on a VI 1-min schedule for the first 20 min.

The following conditioning phases are summarized in Table 1b. All stimuli were presented while Ss were responding for sucrose reinforcement delivered on a VI 2-min schedule. Stimulus effects were assessed in terms of suppression ratios as in Experiment 1.

Excitatory test stimulus (B) training. This phase was designed to establish a flashing light as a conditioned excitor of fear against which the inhibitory properties of X could be tested later in the summation test. In each of four daily 2-hr sessions, Ss received four 1-min B trials, each reinforced with a 1-sec, 1-mA shock.

Simultaneous compound conditioned inhibition training . The next phase of the experiment was designed to establish an intermittent tone (X) as a conditioned inhibitor. In each of the first two 2-hr sessions, Ss received four reinforced noise (A) trials. During each of the following sessions, Ss received six reinforced A trials and six nonreinforced presentations of the noise-tone compound (AX). All stimuli were 1 min in duration; reinforcement was a 1-sec, 1-mA shock. This training

continued for a total of 46 sessions.

Excitatory test stimulus (B) reminder. In a single 2-hr session, Ss were presented four reinforced B trials to insure that, after 48 days without experiencing B, the stimulus continued to control excitatory tendencies.

Recovery. Following conditioning, Ss were allowed to bar press in four daily 2-hr sessions for sucrose reinforcement on a VI 2-min schedule. During these sessions, neither CSs nor USs were presented. This phase of the experiment was designed to minimize any excitatory tendencies controlled by the background cues.

Extinction of excitation to A and inhibition to X. Following recovery sessions, Ss were divided into two groups. There were seven Ss in each group, as two Ss were dropped from the study for failing to learn the discrimination. In each of 10 daily sessions, Ss in Group C continued to bar press for sucrose reinforcement, experiencing no stimuli of any kind. Group E, on the other hand, received a treatment designed to attenuate X's inhibitory properties. In each of the 10 2-hr sessions, Ss in Group E received four nonreinforced presentations each of the A, AX, and X stimuli, superimposed on bar pressing.

Summation test. To assess the ability of X to attenuate excitation, all Ss were presented three B and three BX trials, nonreinforced, in a single 2-hr session. Again, Ss continued to bar press during testing, and stimulus effects were measured in terms of suppression ratios.

Retardation test. Following summation testing, the ability of X to resist excitatory conditioning was tested. All Ss received four X stimulus trials in each of two 2-hr sessions, half of the trials reinforced

with a 1-sec, 1-mA shock.

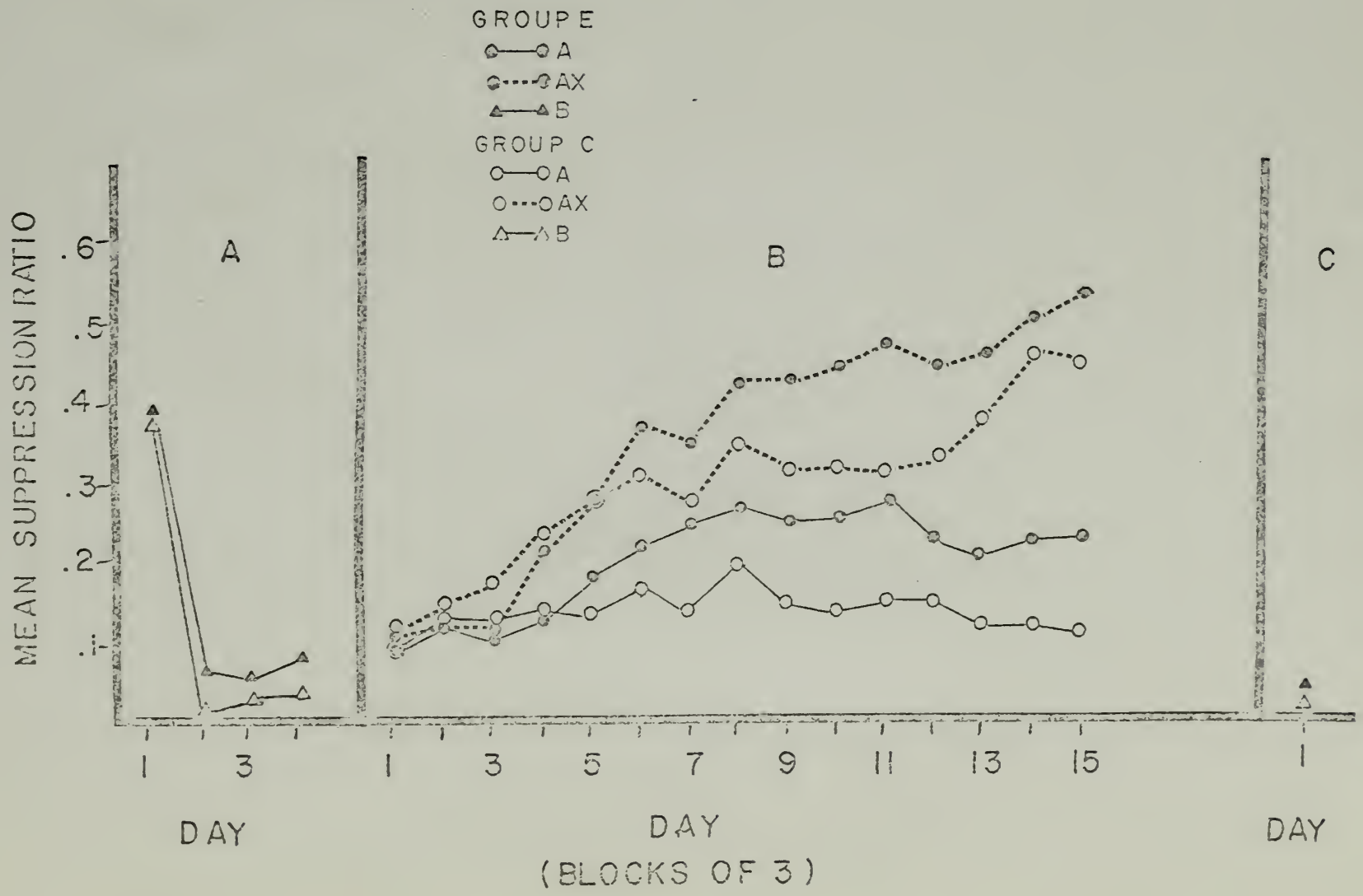
Results

The results of Experiment 2 are presented in Figures 2 and 3. Figure 2 shows the course of preliminary excitatory and inhibitory training. Panel A shows suppression ratios for Groups E and C to B (flashing light) on 4 days of excitatory conditioning; Panel B shows suppression ratios on reinforced A (noise) and nonreinforced AX (noise-tone) trials during initial simultaneous compound conditioned inhibition training for Groups E and C. In Panel B, the data are plotted in terms of mean suppression ratios over blocks of 3 days. The first day of A+, AX- training and the 2 preceding days of A+ training are not shown. Panel C shows suppression ratios to B on the single day of B retraining.

In preliminary training (Panel A), Ss in both groups acquired suppression to B rapidly. During simultaneous compound conditioned inhibition training (Panel B), Ss in both groups came to suppress during A but not during AX trials. A comparison of difference scores (i.e., the difference between suppression on A and AX trials) on the last 3 days of conditioned inhibition training revealed no significant difference between the two groups ($t = -.38$, $df = 12$, $p > .70$, two-tailed), suggesting that the two groups discriminated equally well between A and AX trials. While, over the course of discrimination training, Group C showed greater suppression on both A and AX trials than did Group E, these differences were not significant on the last day of training ($ts < 1.87$, $df = 12$, $ps > .05$, two-tailed). Rats in both groups showed continued suppression to B on the single day of B retraining following conditioned inhibition training.

FACE PAGE FOR FIGURE 2

Figure 2: Mean suppression ratios for Groups E and C in Experiment 2
Panel A: Excitatory test stimulus training
Panel B: Simultaneous compound conditioned inhibition training (3 day blocks)
Panel C: Excitatory test stimulus reminder


GROUP E
A
AX
B
GROUP C
A
AX
B
MEAN SUPPRESSION RATIO
.6
.5
.4
.3
.2
.1
A
B
C
1
3
1
3
5
7
9
11
13
15
1
DAY
DAY
(BLOCKS OF 3)
DAY

FACE PAGE FOR FIGURE 3

Figure 3: Mean suppression ratios for Groups E and C in Experiment 2
Panel A: Extinction (Group E only)
Panel B: Summation test
Panel C: Retardation test

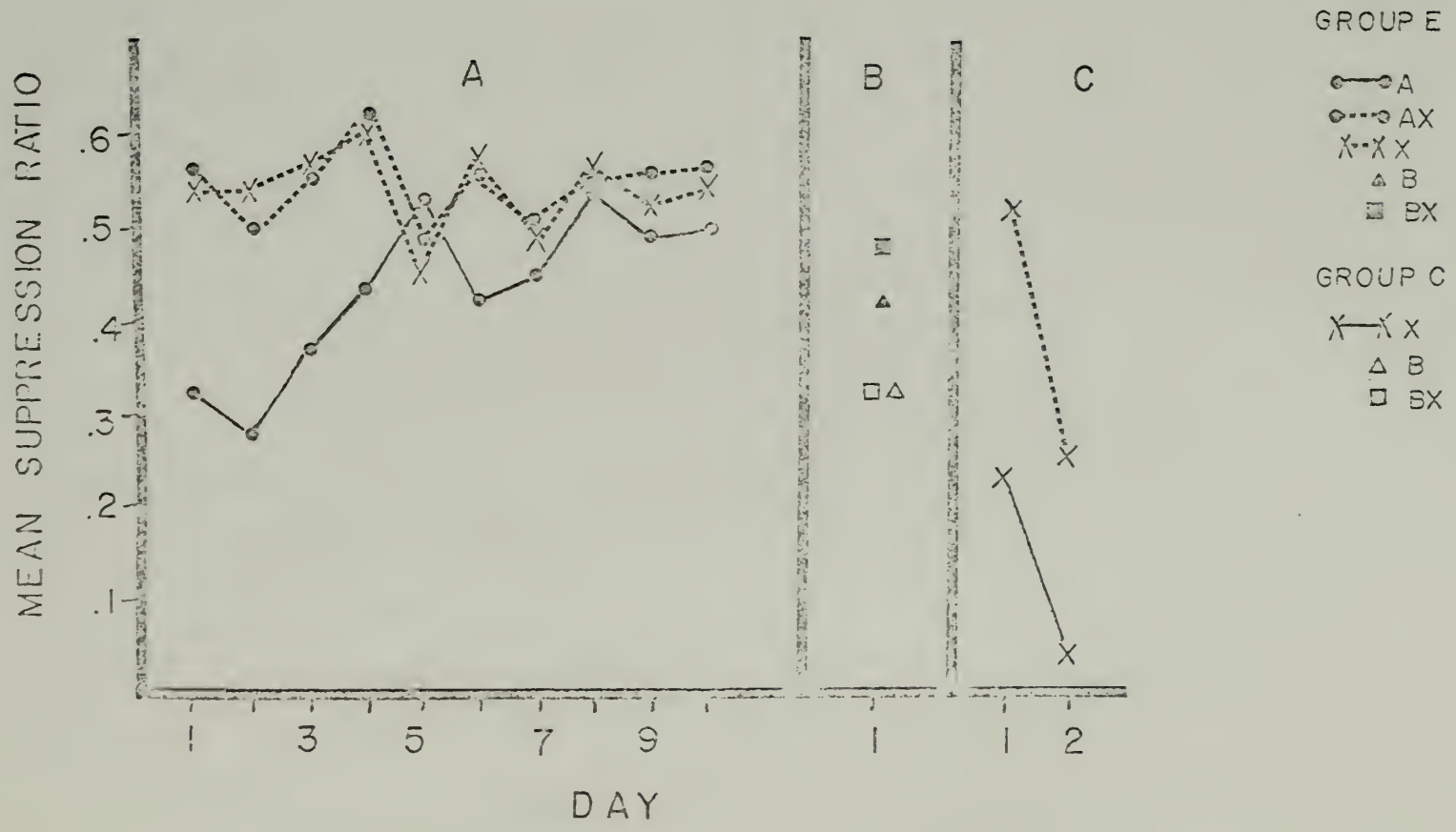

MEAN SUPPRESSION RATIO
.6
.5
.4
.3
.2
.1
A
B
C
1
3
5
7
9
1
1
2
DAY
GROUP E
A
AX
X
B
BX
GROUP C
X
B
BX

Figure 3 shows stimulus effects on responding during the extinction and testing phases of Experiment 2. Panel A shows data for Group E during 10 days of extinction. Group C received no stimulus trials while bar pressing during this period. The figure shows that nonreinforcement of A trials gradually weakened suppression to A and that by the end of 10 days of extinction training, Ss in Group E did not suppress to A presentations. During extinction, suppression ratios to AX and X fluctuated around the neutral .50 mark, and by the end of training there were no significant differences in suppression on A, AX, or X trials ($ts < 1.74$, $df = 6$, $ps > .10$, two-tailed).

The data plotted in Panel B represent mean suppression ratios during summation testing for Groups E and C (averaged over the three trials each of B and BX). Suppression ratios for individual animals on individual trials during testing are presented in Table 3 to provide a more detailed picture of the data. Of major importance is the fact that neither group of Ss showed a statistically significant weakening of suppression to B on BX trials. That is, for both groups, X was not inhibitory. The data in Table 3 show that: 1) For Group E, particularly, suppression to the excitatory stimulus (B) weakened rapidly with nonreinforcement; 2) Particularly in Group C, many Ss suppressed on the first (BX) trials of the session; and 3) There was a good deal of variability among Ss in each group.

If attention is focused on early stimulus trials during summation testing (i.e., before suppression weakened to B), Group E does show a (nonsignificant) tendency to suppress less on BX trials. Referring to Table 3a, if one compares suppression ratios averaged over the first two

Table 3: Experiment 2. Suppression ratios on B and BX trials during summation testing for individual subjects in Groups E and C. Stimulus trials are listed in the order in which they occurred.

	Trial					
Group E Subject	BX	B	BX	B	B	BX
1	.17	.29	.55	.67	.64	.67
2	.00	.03	.64	.14	.69	.50
3	.04	.00	.82	.43	.71	.60
4	.05	.22	.57	.55	.50	.67
5	.58	.47	.70	.53	.50	.67
6	.00	.64	.25	.67	.36	.33
7	.83	.44	.79	.33	.43	.75
Mean	.24	.29	.62	.45	.55	.60

Group C Subject	BX	B	BX	B	B	BX
1	.07	.06	.00	.38	.24	.56
2	.00	.08	.00	.11	.64	.00
3	.00	.63	.62	.65	.60	.61
4	.07	.48	.53	.56	.73	.59
5	.22	.32	.69	.81	.56	.62
6	.00	.12	.15	.00	.00	.57
7	.00	.00	.76	.00	.00	.72
Mean	.07	.24	.39	.36	.40	.52

BX trials with those on the first B trial, it can be seen that 6 of the 7 rats in Group E show an inhibitory summation effect, while only 2 rats in Group C do so (Table 3b). However, a statistical comparison of suppression ratios on the first B and first two BX (averaged) trials reveals no significant summation effect (t=1.1, df=6, $p > .10$, one-tailed). Nor is there a statistically reliable difference between Groups E and C when difference scores for both groups are compared (t=1.01, df=12, $p > .10$, one-tailed).

The results of the retardation test are presented in Figure 3, Panel C, in terms of mean suppression ratios, averaged over four trials, during X trials for both groups. Over the 2 days of testing, Group E was significantly retarded relative to Group C in the acquisition of suppression to X (t=4.24, df=12, $p < .01$, one-tailed).

Discussion

The main conclusion that can be made on the basis of the results of Experiment 2 is that, relative to Group C, the experimental extinction procedure studied did not weaken conditioned inhibition. It was expected that Group C would show a good inhibitory effect against which to measure any decrement in the effect in animals exposed to extinction. In summation testing, however, Group C showed no inhibitory effect, while Group E showed at least a weak inhibitory tendency. One obvious difficulty with the results lies in the extinction of excitation to B during summation testing, thus providing a poor background against which to demonstrate the presence or absence of inhibition. In terms of the summation data, then, one gains only an impression that Group E has an inhibitory tendency

which Group C does not.

The retardation data strengthen the impression that Groups E and C differ in their responses to X as Group E is quite retarded relative to Group C in the acquisition of suppression to X. However, without supporting summation data, it is difficult to draw conclusions as to what that difference really means, although some possibilities are suggested:

1) For both Groups E and C, X may retain (in some undetermined amount) inhibitory properties following extinction and/or recovery sessions. These inhibitory properties may fail to show up in summation testing for reasons associated with the test procedure itself (e.g., the extinction of excitation to the test stimulus). Further, the inhibitory properties of X may be stronger for Group E than for Group C, as supported by the retardation data.

2) For Groups E and C, X may have lost (in some undetermined amount) inhibitory strength following extinction and/or recovery sessions. And, further, X may have lost inhibitory tendencies to a greater extent in Group C than in Group E.

3) Without appropriate control data, it is impossible to determine if the nonreinforced X presentations were sufficient to eliminate or weaken conditioned inhibition. However, the results do suggest that the mere passage of time (as experienced by Group C) may be equally as effective as (or perhaps more effective than) the nonreinforced presentations of inhibitory and excitatory CSs (as experienced by Group E) in weakening conditioned inhibition.

Experiment 3

Experiment 3 was designed to test the possibility that the inhibitory properties of a CS, established through simultaneous compound conditioned inhibition training, might diminish with the passage of time, i.e., that animals having no experience with the inhibitory CS for a period of time following training might "forget" that the CS was an inhibitor.

While the literature indicates that excitation in a conditioned suppression procedure is retained over long periods of time (Hoffman, Fleshler, & Jensen, 1963; Gleitman & Holmes, 1967), it is less clear that inhibition is equally unforgetable. For example, Gleitman and Bernheim (1963) found a loss of typical FI scalloping in rats after a retention period. Prior to experimental treatment, rats given reinforcement contingent on bar pressing on a fixed-interval (FI) 1-min schedule came to place the great majority of their responses in the second half of the 1-min interval. However, following a retention period of 24 days, this temporal discrimination had deteriorated, and Ss greatly increased responding in the first half of the interval. Apparently, Ss "forget that responses just after reinforcement yield no pellets" (p. 841) or, that the first part of the interval is associated with nonreinforcement.

Further, Hammond and Maser (1970) studied the retention of a temporal pattern of responding in a conditioned suppression procedure. Long duration CSs, terminating in shock, generate a pattern of suppression in which suppression is weaker in the first part of the CS than in the later part. This is typical of the long-delay procedure discussed earlier as

one producing inhibition (inhibition of delay), where conditioned responses are inhibited early in the CS (Rescorla, 1967a). Hammond and Maser (1970) found that, when long-delay training was followed by a 25-day retention interval, Ss continued to suppress at previous levels to the CS; however, the temporal pattern of suppression was no longer observed. These two studies, then, may be taken as evidence that inhibition is subject to forgetting.

In Experiment 3, two groups of animals were exposed to simultaneous compound conditioned inhibition training designed to establish a CS as a conditioned inhibitor. One group of animals (C) was then immediately tested for stimulus effects in terms of summation and retardation tests, while the second group of animals (F) sat in their home cages for 30 days (maintained on deprivation schedules) following training and then tested for inhibition. Of interest were any differences in the two groups in the inhibitory strength of the CS. Weakening of inhibitory control in Group F might indicate that conditioned inhibition had been forgotten.

Method

Subjects and Apparatus

Ss were 15 Holtzman albino male rats similar to those of previous experiments. The apparatus was unchanged.

Procedure

Preliminary training proceeded as in Experiment 2. The conditioning phases which followed are summarized in Table 1c.

Simultaneous compound conditioned inhibition training. This phase was designed to establish for all 15 Ss a tonal CS (A) as a conditioned excitor and a flashing light (X) as a conditioned inhibitor.

During two initial 2-hr sessions, Ss received four reinforced presentations of A. In each of the 14 daily 2-hr sessions which followed, Ss experienced six reinforced A trials and six nonreinforced AX trials. All stimuli were 1 min in duration; a 1-sec, 1-mA shock served as reinforcer.

Treatment for Group C. Following conditioned inhibition training, seven of the fifteen Ss were assigned to Group C and treated in the following manner. In two 2-hr recovery sessions, Ss were allowed to bar press while experiencing no stimuli. Then, on a single day of summation testing, Ss in Group C were exposed to three A and three AX stimulus trials, all nonreinforced, in counterbalanced order.

Following this, Ss in Group C experienced on each of 3 days of retardation testing, four X (light-alone) trials, half of them reinforced by a 1-sec, 1-mA shock.

Treatment for Group F. Immediately following the completion of inhibitory training, Ss in Group F were returned to their home cages for a 30 day forgetting period, during which they were maintained on a 24-hr deprivation schedule but were not run in the experimental apparatus. Following this, 2 days of recovery sessions were followed by a single day of summation and 3 days of retardation testing, as in Group C. The only difference, then, between Groups C and F was the interpolation for Group F of 30 days (spent in their home cages) between inhibitory training and testing for inhibitory control.

Results

The results of Experiment 3 are presented in Figure 4 in terms of the mean suppression ratios associated with: 1) reinforced A and nonreinforced AX trials during conditioned inhibition training (Panel A); 2) nonreinforced A and AX trials during summation testing, averaged over all three trials of each stimulus (Panel B); 3) nonreinforced A and AX trials during summation testing, on individual trials (Panel C); and, 4) reinforced X trials during retardation testing.

During inhibition training, Groups C and F acquired the necessary A+, AX- discrimination at similar rates, and all Ss learned to suppress on A trials while continuing to respond on AX trials. At the end of conditioning, there were no significant differences between the two groups ($t=.25$, $df=13$, $p>.70$) in terms of difference scores.

The results of summation testing for conditioned inhibition are shown in Panels B and C. Table 4 presents complete individual subject data for each stimulus trial during testing. In terms of overall results (Panel B), both groups showed a significant summation effect ($ts>2.34$, $df=6$, $ps<.05$, one-tailed) and did not differ significantly from one another (difference scores, $t=.45$, $df=13$, $p>.60$). However, a closer look at the data reveals that neither group demonstrated a significant summation effect throughout testing and, further, that the two groups differed in terms of when the summation effect was present during testing. Group C showed a strong summation effect as measured by the first A and AX presentations ($t=3.59$, $df=6$, $p<.01$), but no significant effect on subsequent A and AX trials ($ts<1.08$, $df=6$, $ps>.10$, one-tailed). On the other hand, Ss in Group F suppressed completely on both the first A and

FACE PAGE FOR FIGURE 4

Figure 4: Mean suppression ratios for Groups C and F in Experiment 3
Panel A: Simultaneous compound conditioned inhibition training
Panel B: Overall summation test
Panel C: Individual trials in summation test
Panel D: Retardation test

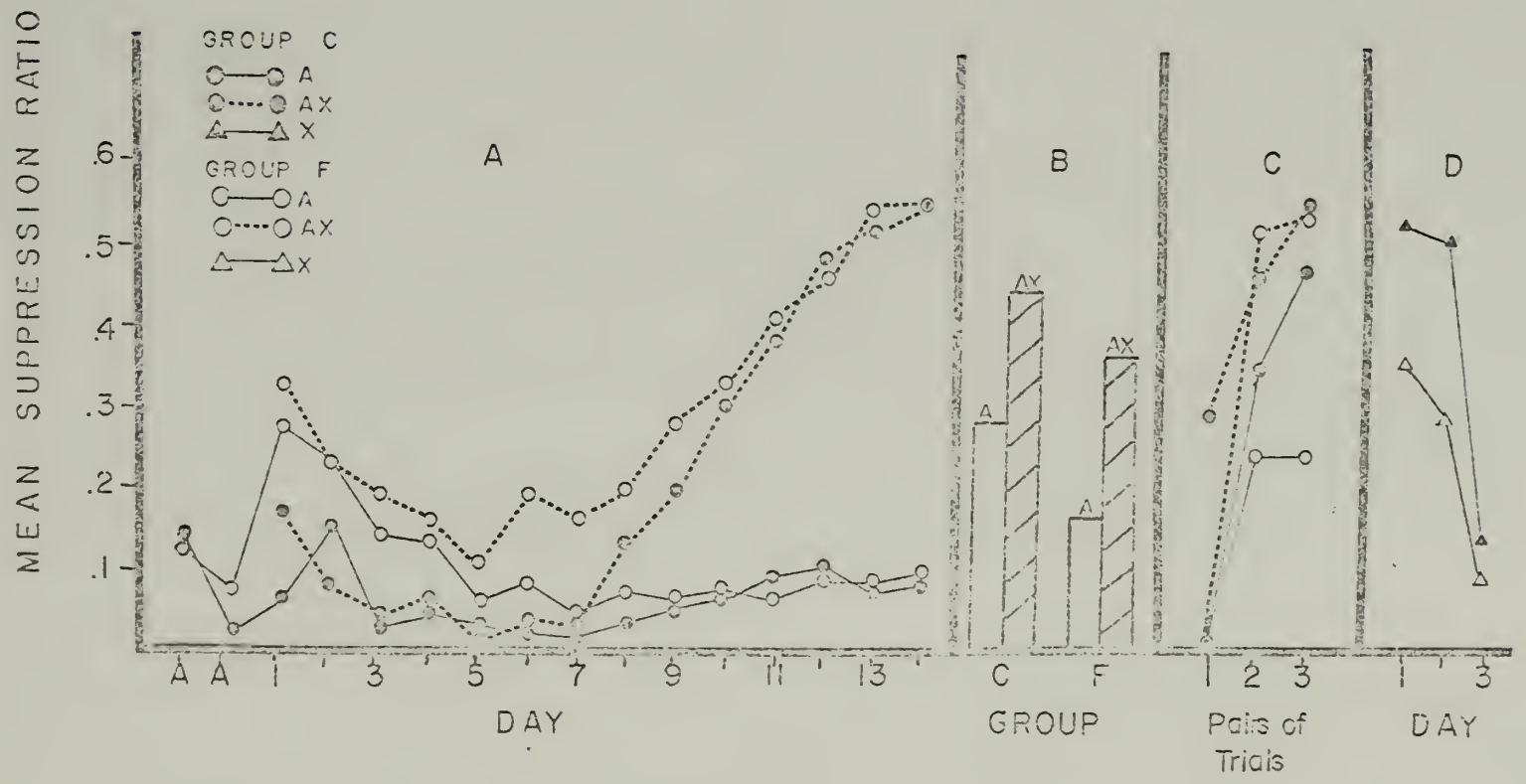

MEAN SUPPRESSION RATIO
GROUP C
A
AX
X
GROUP F
A
AX
X
.6
.5
.4
.3
.2
.1
A
B
C
D
A A 1 3 5 7 9 11 13
DAY
C F
GROUP
1 2 3
Pairs of Trials
1 3
DAY

Table 4: Experiment 3. Suppression ratios on A and AX trials during summation testing for individual subjects in Groups C and F. Stimulus trials are listed in the order in which they occurred.

	Trial					
Group C Subject	AX	A	AX	A	A	AX
1	.52	.06	.43	.50	.59	.48
2	.48	.00	.43	.60	.38	.45
3	.00	.00	.38	.29	.73	.75
4	.42	.00	.56	.00	.11	.40
5	.24	.00	.45	.52	.46	.44
6	.38	.00	.48	.00	.33	.59
7	.00	.00	.50	.50	.80	.71
Mean	.29	.01	.46	.35	.47	.55

Group F Subject	AX	A	AX	A	A	AX
1	.00	.00	.30	.00	.17	.50
2	.00	.00	.44	.64	.64	.20
3	.00	.00	.53	.00	.36	.68
4	.00	.00	.42	.25	.00	.47
5	.00	.00	.44	.00	.00	.77
6	.00	.00	.71	.57	.33	.53
7	.00	.00	.57	.21	.30	.46
8	.00	.00	.71	.25	.14	.71
Mean	.00	.00	.52	.24	.24	.54

the first AX trials, but showed a significant attenuation of suppression to A on subsequent AX trials ($ts > 2.35$, $df=7$, $ps < .05$, one-tailed). In all cases significance was determined in terms of a comparison of suppression ratios to A versus AX on each of the three pairs of A-AX trials.

Retardation results for Groups C and F are presented in Figure 4 (Panel D). Ss in Group F acquired suppression to X significantly faster than did Ss in Group C ($t=2.69$, $df=13$, $p < .01$, one-tailed).

Discussion

The main finding of this experiment is that a prolonged delay between simultaneous compound conditioned inhibition training and the test for inhibition thus established does, in fact, appear to have a detrimental, though temporary, effect upon inhibition. Ss in Group F responded quite differently, in comparison to Ss in Group C, on the first trial of the AX stimulus in summation testing; the former suppressed to the stimulus, while the latter showed attenuation of suppression. Ss in Group F had not permanently forgotten the inhibitory nature of X, for a strong summation effect was shown later in testing. In contrast, Ss in Group C showed a strong summation effect early in testing, which washed out later in testing as excitation to the A stimulus extinguished. It should be noted that Ss in the forgetting control group in Experiment 2 (Group C) also suppressed on the first compound trial in summation testing, but did not show a summation effect in subsequent testing.

For Group F, then, the presentation of either the first A or the first AX cue in summation testing appears to have performed the role of prompting the inhibitory control of X, even though neither of the stimulus

trials was accompanied by shock.

That one or both of these cues may have been responsible for the recovery of the summation effect in Group F calls to mind the "reinstatement" effect of Rescorla and Heth (1975). If the effect here is a true prompting effect, it might be possible to interpret the action of the cues as involving some modifications of the US or not-US image after one or both of these had been previously modified during the retention interval. Alternatively, the effect might be explained in terms of a reestablishment, with the presentation of the A and AX stimuli, of the general stimulus context in which inhibitory conditioning took place (Mackintosh, 1974). It should be noted that the extinction procedures examined in Experiments 1 and 2 could perform a similar role in maintaining the conditions of inhibitory training, or prompting the conditioned response, and thus maintaining inhibition.

One further note on the prompting notion discussed above: Baker (1977) found that inhibitory effects arising from a negative correlation procedure (and reliably demonstrated in a retardation procedure) were not observed in a compound test procedure involving nonreinforced A and AX trials (i.e., a summation procedure). However, when, in continued compound testing, he reinforced the A-alone stimulus, a good attenuation of excitation effect was immediately apparent on subsequent trials. Here, the shock appeared to perform a prompting role. By adding shock, the summation procedure became a conditioned inhibition savings test similar to the one used here in Experiment 1. In fact, the responses of both groups of animals in Experiment 1 on the very first few B and BX trials during testing (see Table 2) suggest that the presentation of

shock may have prompted the inhibitory control of X.

The retardation results of Experiment 3 are consistent with the conclusion that, for Group F, some impairment in the inhibitory power of X has taken place. However, the strong summation effect demonstrated late in summation testing makes this explanation of the retardation results less agreeable. Possibly, the facilitated excitatory acquisition in Group F was (in part or entirely) a function of an "incubation of fear process" (McMichael, 1966; Denny & Ditchman, 1962), in which fear conditioned to an excitatory CS becomes increasingly greater during retention intervals. It is consistent with this notion that, during summation testing, Ss in Group F continued to suppress well on A trials throughout testing, whereas, for Ss in Group C, the excitatory strength of A extinguished rapidly. An incubation of fear effect may also have contributed in part to the suppression shown by Group F early in summation testing. Finally, the inclusion of a control procedure, involving shock and retention interval (but not inhibitory) experience similar to that of Group F might clarify the retardation results.

Experiment 4

In Experiments 1 and 2 the nonreinforced presentations of conditioned inhibitors was investigated as a procedure leading to the attenuation of conditioned inhibition. In Experiment 4, the negative correlation between the inhibitory CS and the US was removed in an attempt to extinguish the tendencies controlled by the inhibitory CS. Zimmer-Hart and Rescorla (1974) investigated two procedures (A and AX trials, either both reinforced or neither reinforced) designed to degrade the negative CS-US

correlation developed through simultaneous compound conditioned inhibition training. In that experiment, only in the instance where both A and AX were reinforced did X lose its inhibitory properties. In the present experiment, the correlation between the conditioned inhibitor and reinforcement was removed in a different way, by presenting the inhibitor (X) and the shock in a truly random fashion. That is, CS (X) and US trials were programmed to occur randomly and independently of one another, such that the probability of a US was equal in CS presence and absence. Such a procedure, in which the CS is no longer informative about the occurrence of nonreinforcement or reinforcement, has been suggested as an appropriate method of extinguishing both inhibition and excitation (Rescorla, 1967b).

In terms of the Rescorla-Wagner model, a truly random procedure might be expected to reduce inhibition. The independent and random presentation of CSs and USs involves stimulus trials of the following types: 1) CS-alone; 2) US-alone; and 3) chance pairings of the CS and US. Both reinforced and nonreinforced CS trials should contribute to a reduction in inhibition controlled by the CS as a result of prior inhibitory training. On the other hand, US-alone trials should raise the excitatory strength of the background cues, which might attenuate the loss of inhibition on nonreinforced X trials or perhaps even increase X's inhibitory strength.

Subjects in one group (Group E) experienced typical simultaneous compound conditioned inhibition training designed to establish two stimuli (X and Y) as conditioned inhibitors, followed by experience with one of the inhibitors (X) presented in a truly random fashion with shocks, while A+ trials continued to be presented as before. The ability of X,

relative to Y, to control inhibitory tendencies was assessed in terms of summation and retardation procedures.

A second group of Ss (Group N) did not receive conditioned inhibition training, but did receive excitatory training to the A stimulus (as did Group E) and, following that, truly random training with X. Then summation and retardation tests were used to assess the conditioned properties of X. Theoretically, the truly random treatment should leave X neutral (Rescorla, 1967a). Group N was included in the design to reveal the actual effects of the truly random training experience on naive subjects. Group N was not intended as a control for Group E.

Method

Subjects and Apparatus

Sixteen male albino rats similar to those of the preceding experiments served as subjects in the same apparatus. Animals were food deprived, and bar pressing was reinforced with sucrose presentations.

Procedure

Preliminary training proceeded as in Experiment 2. The conditioning phases which followed preliminary training are summarized in Table 1d.

Simultaneous compound conditioned inhibition training. This phase was designed to establish, for one group of eight Ss (Group E), a 75-dB white noise stimulus (A) as a conditioned excitor, by reinforcing A presentations; while two other stimuli, a flashing light and intermittent tone (see Experiment 2), were established as conditioned inhibitors by presenting them in compound with the A stimulus, nonreinforced.

During the first two 2-hr sessions, Ss received four reinforced presentations of A. During each of the following sessions, each animal received four reinforced A trials and four nonreinforced presentations of each of the compound stimuli (AX and AY). All stimuli were 1 min in duration; reinforcement was a 1-sec, 1-mA shock. Training with the three stimuli (A, AX, and AY) continued for 41 days.

A second group of eight Ss (Group N) received the same reinforced A trials as did Group E throughout this phase of the experiment, but experienced no compound trials.

Extinction of inhibition. This phase was designed to degrade, for Group E, the correlation between nonreinforcement and one of the stimuli established as conditioned inhibitors in the previous phase. At this time, one of the Ss in Group E was dropped from the experiment for failure to form the discriminations during the previous phase. For four of the seven Ss of Group E, the inhibitory stimulus to be extinguished (X) was the flashing light (Subgroup E-L), while for the other three Ss, the X stimulus was the intermittent tone (Subgroup E-T).

On each day of extinction, Ss in Subgroups E-L and E-T received two reinforced white noise trials (A), designed to maintain A as an excitor. In addition, Ss received 24 X trials and 10 1-sec, 1-mA shocks presented randomly and independently of one another. The random schedule of presentations of CSs (X) and USs was computer generated, with the restriction that the number of pairings of CS and US occurring per session had to be equal to the number of CS-US pairings that would theoretically occur by chance (i.e., two). This conditioning continued for 8 days.

In order to monitor the ongoing changes in the degree of inhibition controlled by X and Y during this period, a single nonreinforced AX or AY trial was superimposed upon responding on alternate days of truly random training.

The eight Ss in Group N received training identical to that of Subgroups E-L and E-T in this phase of the experiment. Again, four Ss experienced light as the X stimulus (Subgroup N-L) and four Ss experienced tone (Subgroup N-T).

Recovery. In four 2-hr sessions, Ss in all groups were allowed to bar press for reinforcement on a VI 2-min schedule while no stimuli or shocks were presented. This procedure was designed to insure a nonexcitatory background against which to test the effects of interest.

Summation test. This phase was designed to assess the ability of X and Y to attenuate suppression controlled by A. Ss in all groups received two A, two AX, and two AY trials, all nonreinforced, superimposed on responding in a single 2-hr session.

Retardation test. In this phase, the inhibitory properties of both X and Y were assessed in terms of a retardation test. In each of six daily 2-hr sessions, Ss in all groups received two presentations each of the X and Y stimuli, one of each reinforced with a 1-sec, 1-mA shock.

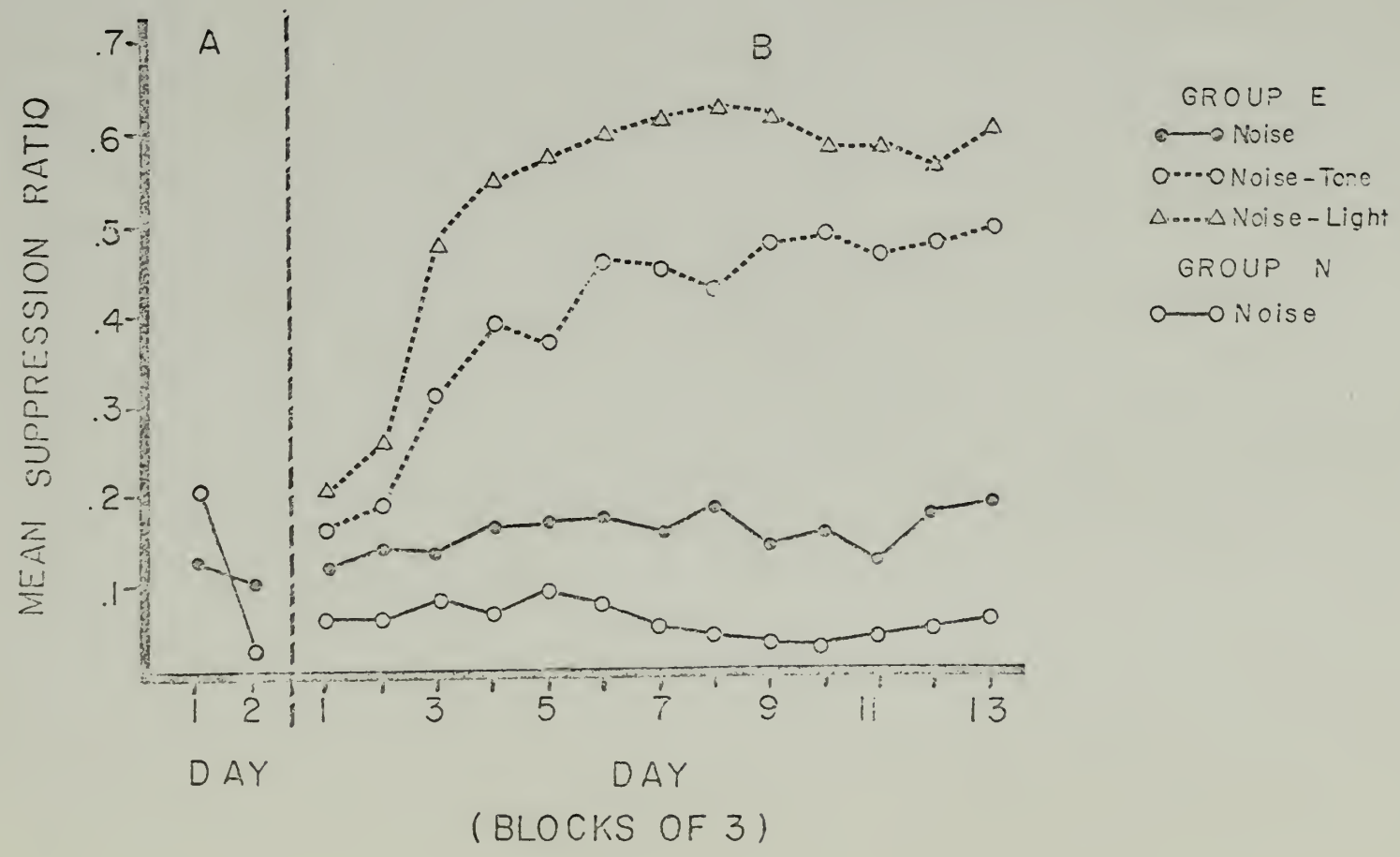
Results

Group E

The results of preliminary excitatory and inhibitory training for Group E are presented in Figure 5.

FACE PAGE FOR FIGURE 5

Figure 5: Mean suppression ratios for Groups E and N in Experiment 4
Panel A: Preliminary A+ training
Panel B: Simultaneous compound conditioned inhibition training


MEAN SUPPRESSION RATIO
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(BLOCKS OF 3)
GROUP E
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Noise - Tone
Noise - Light
GROUP N
Noise

Panel A in Figure 5 shows preliminary A+ conditioning results. Suppression to A was rapidly acquired in Group E. Panel B shows simultaneous compound conditioned inhibition training results for Group E. Data are plotted in 3-day blocks, with the first 2 days of training omitted. These results show that both the noise-light/noise and noise-tone/noise discriminations were gradually formed. The noise-light/noise discrimination was formed more rapidly; and, on the last day of training, Ss in Group E suppressed significantly less during noise-light trials than during noise-tone trials ($t=3.06$, $df=6$, $p<.05$, two-tailed).

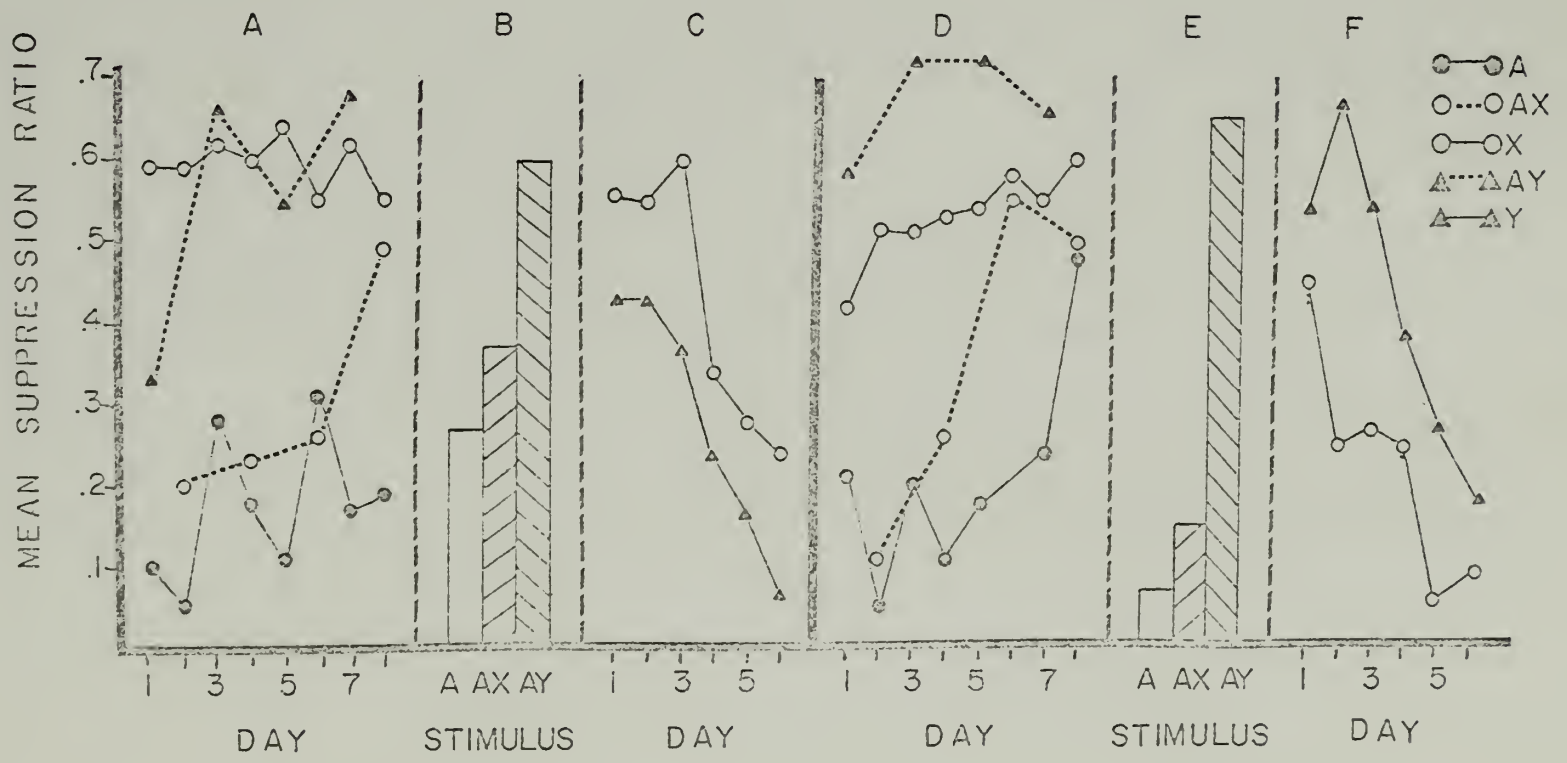
Data representing the mean effects of A, X, and (alternating) AX and AY stimuli on each day of truly random training for Subgroups E-L and E-T are presented in Figure 6 (Panels A and D, respectively). For Subgroup E-L, X was the light and Y the tone, while for Subgroup E-T the opposite was true. Each data point for A is based on two trials; each point for X on 24 trials; and each point for AX and AY on only one trial.

The data for Subgroups E-L and E-T are similar. Ss continued to suppress to A throughout training. Ss did not suppress on X trials, and, in general, did not suppress on AY probe trials. A comparison of suppression to AX on the last day of conditioned inhibition training and on the first AX probe, reveals a significant increase in suppression during AX ($t=4.69$, $df=6$, $p<.01$). A similar comparison of suppression to AY reveals no significant change ($t=1.53$, $df=6$, $p>.10$). Both comparisons are based on data pooled across subgroups.

The suppression to AX early in truly random training lessened during training, and animals in both subgroups suppressed significantly less on the last AX probe than the first (pooled data, $t=9.45$, $df=5$, $p<.001$).

FACE PAGE FOR FIGURE 6

Figure 6: Mean suppression ratios for Subgroups E-L and E-T in Experiment 4
Panel A: Extinction (E-L)
Panel B: Summation test (E-L)
Panel C: Retardation test (E-L)
Panel D: Extinction (E-T)
Panel E: Summation test (E-T)
Panel F: Retardation test (E-T)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Summation data for Subgroups E-L and E-T are shown in Figure 6, Panels B and E, respectively. The data are similar in form, though absolute suppression levels differ between subgroups. While animals in both subgroups suppressed on A and AX trials, they did not suppress during AY presentations, irrespective of the nature of the X and Y stimuli (i.e., whether they were light or tone). A comparison (based on pooled data) of difference scores (i.e., the difference between suppression ratios on A and AX trials) on the last day of conditioned inhibition training and during summation testing reveals a statistically significant decrease in the ability of X to attenuate suppression to A following truly random training ($t=4.59$, $df=6$, $p<.01$). A similar (pooled) comparison of difference scores for suppression ratios on A and AY trials reveals no significant change in the ability of Y to attenuate suppression ($t=.77$, $df=6$, $p>.40$).

Retardation data for Subgroups E-L and E-T are presented in Figure 6, Panels C and F, respectively. For both groups, the tonal CS acquired suppression more rapidly than did the light. Averaging over 6 days of retardation testing and pooling data from both subgroups, this difference is significant ($t=6.96$, $df=7$, $p<.001$, two-tailed).

Group N

Data for Group N during preliminary A+ and continued A+ training are presented in Figure 5, Panels A and B, respectively. Suppression to A was rapidly acquired and continued strongly over the 41 days of training. It might be noted that Ss in Group N consistently suppressed more to A than did Ss in Group E during this phase of the experiment. This difference may be due to the fact that Ss in Group N never experienced nonreinforced

trials.

The data representing stimulus effects during truly random training for Subgroups N-L and N-T are presented in Figure 7, Panels A and D, respectively. In both subgroups, Ss continued to suppress to A throughout training. Ss in both subgroups showed essentially no suppression on X trials, while suppression on AX trials was similar to that on A alone trials. Although Ss in Subgroup N-T (Panel D) suppressed somewhat less on AY trials than on A trials, this difference was not significant (t=1.89, df=6, $p > .10$, two-tailed).

Summation test results for Subgroups N-L and N-T are presented in Figure 7, Panels B and E, respectively. Ss suppressed significantly less on AY trials than on AX trials (t=3.85, df=7, $p < .01$, two-tailed) regardless of the nature of the X and Y stimulus (pooled data).

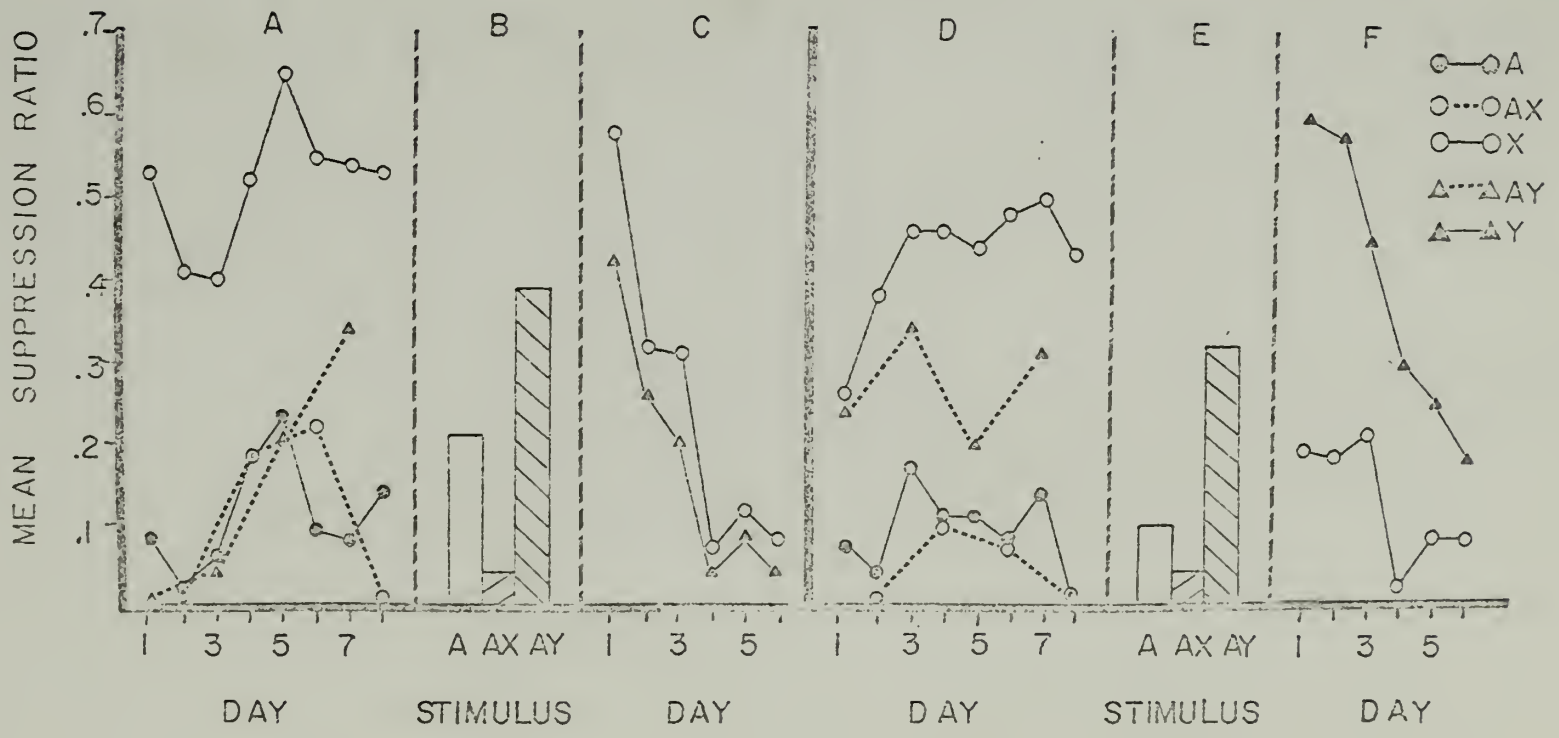
Retardation data for Subgroups N-L and N-T are presented in Figure 7, Panels C and F, respectively. For both groups, the tone stimulus acquired excitation faster than did the light. Averaging over the 6 days of retardation testing and pooling data for the two subgroups, this difference is significant (t=4.02, df=7, $p < .01$, two-tailed).

Discussion

To summarize the results of Experiment 4 with respect to Subgroups E-L and E-T: 1) All Ss formed both the noise-light/noise and the noise-tone/noise discriminations during inhibition training; the noise-light/noise discrimination was the stronger of the two; 2) Early in truly random training, Ss in both subgroups suppressed on A and AX trials, but not on AY trials; the suppression to AX decreased as training continued;

FACE PAGE FOR FIGURE 7

Figure 7: Mean suppression ratios for Subgroups N-L and N-T in Experiment 4
Panel A: Extinction (N-L)
Panel B: Summation test (N-L)
Panel C: Retardation test (N-L)
Panel D: Extinction (N-T)
Panel E: Summation test (N-T)
Panel F: Retardation test (N-T)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DAY
DAY
STIMULUS
DAY

3) In summation testing, X (light or tone) was no longer able to attenuate suppression to A, while Y was as able to attenuate suppression to A as it had been prior to truly random experience; and, 4) Acquisition rates during retardation testing appeared to be a function of stimulus type rather than previous treatment; the results were confounded by the possibility that the stimuli differed in ways which would contribute to their abilities to acquire associative strength in general (e.g., their salience).

The main finding of the experiment, then, is that the truly random procedure was successful in weakening the inhibitory power of X. That is, when an inhibitory stimulus was experienced along with reinforcement delivered in a noncorrelated manner, that stimulus became less inhibitory. Moreover, the effects of the extinction procedure were specific to the one inhibitory stimulus (X) which was experienced in a truly random fashion with respect to shock; the ability of a second inhibitory stimulus (Y) to attenuate excitation was not diminished. In contrast to data which indicate that truly random treatments are slow to reduce previously established excitatory tendencies (Ayres & DeCosta, 1971; Keller, Ayres, & Mahoney, 1977), the effects of the truly random treatment on X's inhibitory power were almost immediate (according to the AX probe data) and certainly robust (according to the summation data).

By focusing on the data for Subgroups N-L and N-T, it is possible to surmise just how experience with this truly random schedule affected responding in the presence of the various stimuli involved. It seems likely that the major effect of the truly random experience on Ss in the naive groups (Group N) was to condition mild excitation to X. The main

piece of evidence for this is the significantly greater suppression on AX as opposed to AY trials in summation testing for these Ss. It appears highly unlikely that this difference is a result of some inhibitory tendency controlled by Y; the Y stimulus was experienced by these Ss on only the four AY probe trials during truly random training and this seems quite insufficient to develop inhibition in light of the extensive training required by Ss in Group E. On the other hand, it is not at all unlikely that X may have acquired excitation as a result of truly random training (which involved some chance pairings of X with shock). There is much experimental data showing that such a treatment may produce excitatory conditioning (e.g., Benedict & Ayres, 1972; Kremer, 1971; Quinsey, 1971). It should be noted that X-alone trials during the truly random treatment did not suppress responding for Ss in Subgroups N-L and N-T. Reberg (1972) has shown that a stimulus which has been experienced in only a few excitatory acquisition trials, or to which excitation has been extinguished, and which has no obvious suppressive effect when presented alone, does reveal excitatory tendencies when presented in compound with a second excitatory stimulus. That is, when a mildly excitatory stimulus (CS_2), which has no suppressive effects by itself, is compounded with a known excitatory stimulus (CS_1), the excitatory tendencies summate to produce greater suppression of responding than is apparent in the presence of CS_1 alone. Thus, in this experiment, a mildly excitatory X stimulus may have no effect on responding when presented alone (as during truly random training), but may act to suppress responding when presented in compound with A, a known excitor (as in summation testing). In fact, Ss in Group N suppressed more (albeit

nonsignificantly) on AX than on A trials during summation testing.

Certainly, X does not become inhibitory as might be predicted on the basis of so many nonreinforced X trials occurring in the presence of background cues which might be excitatory due to US-alone trials.

It is possible that, during the course of truly random training, X becomes excitatory for Ss in Subgroups E-L and E-T, as well. Certainly, the suppression on early AX probe trials is consistent with this notion, as is the gradual weakening of that suppression as training continues (Keller, et al., 1977). However, summation test results suggest that X has acquired a neutral status. It should be noted that the same truly random sequence may have produced an excitatory X in Group N and a neutral X in Group E, given the differences in previous experience between the two groups.

General Discussion

The main findings of this group of experiments are:

1) Nonreinforced presentations of the stimuli involved in previous simultaneous compound conditioned inhibition training (A, AX, and X) do not appear to weaken inhibition thus established; this is consistent with previous experimental evidence (Zimmer-Hart & Rescorla, 1974).

2) The interpolation of a retention interval of 30 days (spent in home cages) between simultaneous compound conditioned inhibition training and testing appears to produce a measurable, but temporary, disruption of the ability of the inhibitory stimulus to attenuate suppression.

3) The truly random presentation of an inhibitory stimulus (X) and shock, which degrades the correlation between X and nonreinforcement, does produce a loss of inhibitory strength in X.

The effects of nonreinforced stimulus presentations are best assessed by an examination of the first three experiments together. Experiment 1 strongly suggests that A-, AX-, and X- experience does not attenuate inhibition in X. Here, the conditioned effects of X were measured by a conditioned inhibition savings test. In contrast, Experiment 2 showed (for Group E) a loss of inhibition following A-, AX-, and X- experience. However, Group C in Experiment 2, which received no such experience, also showed a weakening of inhibition. In both cases, inhibitory effects were tested in a summation procedure. While it is possible that, for Ss in both Groups E and C, X lost inhibitory control (due either to the extinction procedure or the passage of time), this appears unlikely. The results of Experiment 3 suggest that any effect of the retention interval on inhibition is temporary. If this is so, then for Ss in Group C, X might have been expected to recover its inhibitory control during testing. This was not the case. And, while it is still possible that the failure to find summation effects in Group E was due to the effects of the extinction procedure, it now seems more likely that the real culprit was the testing procedure and the failure of the excitatory test stimulus to maintain its ability to suppress responding during testing. This problem is not new in this laboratory (Witcher, 1974; Witcher & Ayres, in prep.). The summation effects shown in Experiment 3 may be better than those of Experiment 2 largely because of relatively better suppression to the excitatory stimulus.

It appears, then, that the presentation of nonreinforced stimuli subsequent to simultaneous compound conditioned inhibition training does not attenuate inhibition. Clearly here, and elsewhere (Baker, 1974; Zimmer-Hart & Rescorla, 1974), the Rescorla-Wagner model is not successful in predicting the effects of nonreinforcement following inhibitory conditioning.

The results of Experiment 3 suggest that the inhibitory control of a CS is not destroyed over a retention period, but rather that the recall of such control is impaired, such that a prompting experience is needed to spark the inhibitory effects of the stimulus. On the surface, then, it appears that inhibition may be more labile than excitation in this regard. For example, within the same experimental situation, excitatory conditioning appears to be absolutely stable over long intervals. Table 5 shows data from Experiment 2 for conditioning to the B stimulus, which was conditioned prior to conditioned inhibition training and then retrained 49 sessions later. There was no loss in suppression to B.

A more direct test of the effects of passing time on excitation versus inhibition is suggested in Table 6. Here, Ss receive either excitatory or inhibitory training prior to a retention interval and subsequent testing for the stimulus effects of excitatory, inhibitory or neutral stimuli. Group 1 is similar to Group F in Experiment 3; Group 2 receives differential as opposed to simultaneous compound conditioned inhibition training; Group 3 receives only excitatory conditioning; and Group 4 acts as a naive control. For completeness, three other groups, ressembling Groups 1, 2, and 3, except for retention interval experience,

Table 5: Experiment 2. Individual subject suppression ratios on:

A) The last B+ trial during preliminary B training

B) The first B+ trial on the single day of B reminder

		Subject							
A.	Group	1	2	3	4	5	6	7	8
	E	.07	.00	.00	.00	.00	.00	.20	.00
	C	.00	.00	.00	.05	.16	.28	.00	.00

B.	Group	1	2	3	4	5	6	7	8
	E	.00	.00	.00	.03	.00	.00	.00	.00
	C	.00	.00	.00	.00	.00	.00	.00	.00

Table 6: Types of stimulus events schedules during the various stages of the proposed experiment on retention effects in excitatory and inhibitory conditioning for four experimental groups. Plus signs (+) indicate reinforcement; minus signs (-) indicate nonreinforcement.

Group	Preliminary conditioning	Retention interval*	Compound testing	Acquisition testing
1	A+, AX-	Yes	A-,AX-	A+, X+
2	A+, X-	Yes	A-,AX-	A+, X+
3	A+	Yes	A-,AX-	A+, X+
4	None	None	A-,AX-	A+, X+

*Could take place in home cages or conditioning chambers

should be run. A further experimental manipulation of interest might be the site of the retention experience (i.e., home cages or experimental chambers). To the extent that the conditioning of the apparatus cues is an important mediating factor in the conditioned strengths of the principal cues, retention experience in experiemntal chambers might be expected to have a greater effect on subsequent stimulus effects upon responding.

The truly random sequence (Experiment 4), which involved X-alone, US-alone, and chance X-US pairings, did attenuate inhibition. It did not (as might have been expected in light of the many X-alone trials occurring in the presence of - possibly - excitatory background cues) increase X's inhibitory power. This is consistent with previous work in this laboratory in which a negatively correlated sequence of CSs and USs which approximated a truly random control (i.e., the probability of shock in CS presence (.6) was <u>almost</u> as great as the probability of shock in CS absence (.8)), failed to produce inhibitory conditioning (Witcher, 1974; Witcher & Ayres, in prep.).

In light of the data from Group N in Experiment 4, it is likely that the important factor in the ability of the truly random control to weaken inhibition is the chance pairings of X with shock. Certainly, Experiments 1 and 2 suggest that the X-alone trials were not sufficient to attenuate inhibition.

One interesting avenue of future research might be to examine in some detail the characteristics of the truly random treatment which are necessary and/or sufficient to extinguish inhibition (see Benedict & Ayres, 1972; Keller, Ayres & Mahoney, 1977; Ayres, Benedict & Witcher, 1975, for examples involving the removal of excitation via truly random

treatment). Such experiments might delineate the important differences between Experiments 1 and 2 and Experiment 4 which contributed to failure (in the first two) and success (in the latter) in the extinction of inhibition.

In addition, it would be interesting to study the degree of exposure to a truly random sequence which is necessary and sufficient to weaken inhibitory control. In Experiment 4, it appears that surprisingly little experience with the truly random procedure is necessary to weaken inhibition.

An inhibitory stimulus has been defined thus far as one controlling a response tendency which opposes the response tendencies of a conditioned excitor (Rescorla, 1969b). Within this framework, training of the A+, AX- variety causes X to evoke a negative associative strength which balances the excitatory associative strength of A, such that the compound presentation of A and X fails to evoke a conditioned response. Nonreinforced presentations of X during extinction procedures evoke this negative response tendency in the absence of a supporting outcome, resulting, theoretically, in a diminishing of that response tendency. The experiments described above fail to support this view.

An alternate view of conditioned inhibition is, however, consistent with the data presented here. This view suggests that an inhibitory CS does not control a response tendency in opposition to excitation. Rather, the conditioned inhibitor is seen to modulate the effectiveness of the conditioned excitor by raising the threshold for excitatory action (Konorski, 1948; Rescorla, 1973; Zimmer-Hart & Rescorla, 1974). Within this framework, an inhibitor has an effect only in the presence of

excitation.

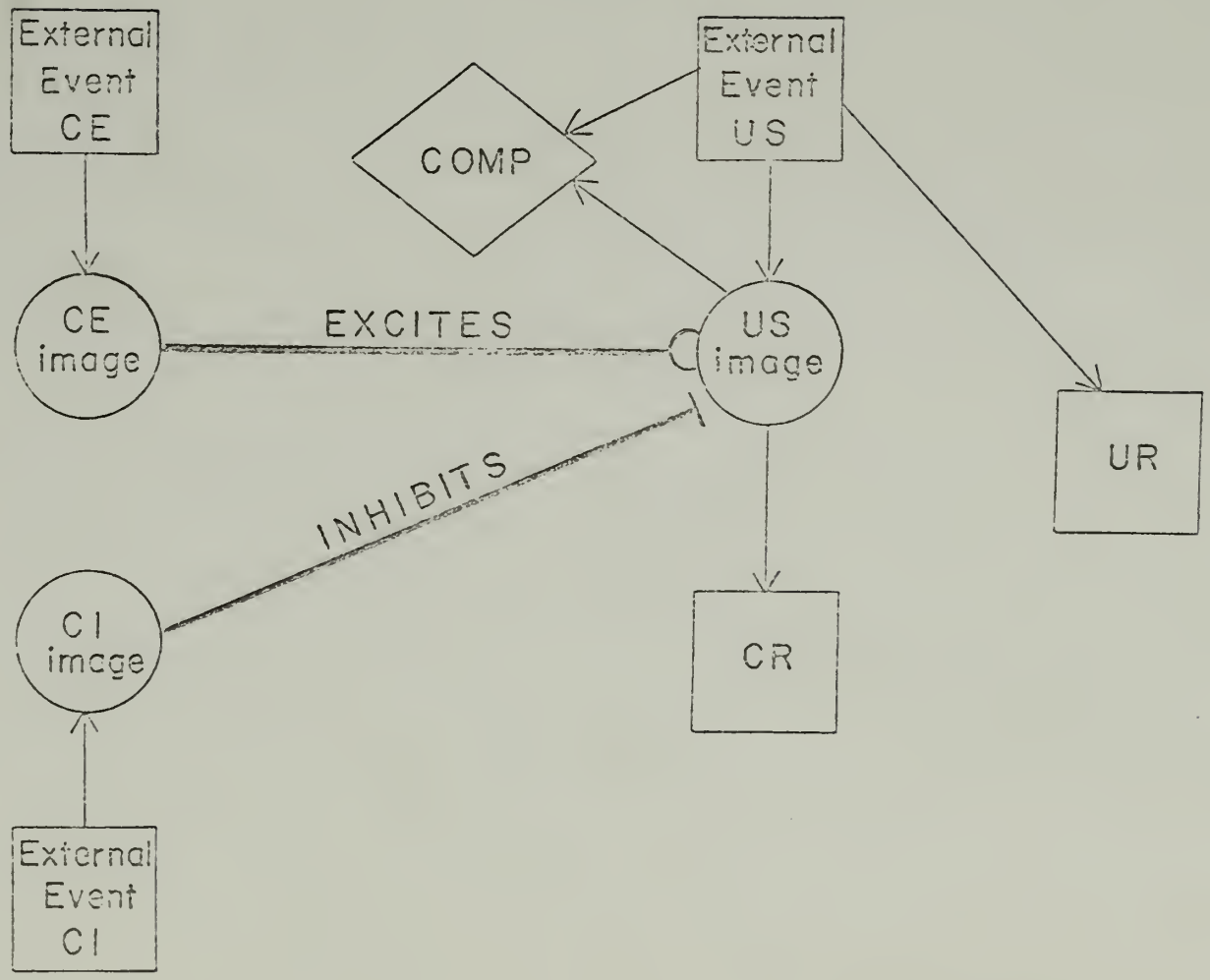
Figure 8 presents a diagram of this alternate view (following Rescorla, 1975) in terms of the internal representations, or "images," of external events and the associative connections between them. Here, too, learning is a function of discrepancies between actual events and the organism's expectations about events. This is represented by a comparison process involving the degree of arousal of the US image and the intensity of the external event. Positive discrepancies develop the excitatory connections shown between CE and US, so that the occurrence of the CE produces a response (CR). Negative discrepancies attach inhibitory processes to the CI. Here, the CI does not excite a "not-US" or "safety" image, but rather inhibits the already established action of CE. To put it another way, rather than establishing competing excitatory connections (i.e., those between CE and US versus those between CI and not-US), inhibitory conditioning arranges a different relationship among existing events (i.e., the CE and US images)(Rescorla, 1975).

Rescorla and Holland (1977) have suggested that the inhibitory action of X (following simultaneous compound conditioned inhibition training) may potentially impinge upon the CE image, the US image, the CR effector, or the excitatory association itself between CE and US. In a study of the transfer of Pavlovian conditioned inhibition across stimuli and responses, the experimenters established that:

1) Inhibition established through training with one exciter (A) would transfer to a second excitor (B) whose excitation was based on the same US (either food or shock). Further, this transfer took place even though excitation had been extinguished to A prior to transfer.

FACE PAGE FOR FIGURE 8

Figure 8: Internal representations, external events and associative connections in conditioning


External Event CE
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2) The transfer of inhibition from A to B occurred even when A and B, though established as excitors by the same US, produced qualitatively different CRs.

3) X did not inhibit responding produced by A when A was subsequently paired with a new US (food became shock); at the same time X continued to inhibit responding produced by B (based on food as a US).

These results argue against the site of inhibitory action being either the CE, the CR or the association between the CE and the US for: 1) Inhibition transferred readily to a new CE; 2)Inhibition transferred readily from one CR to another, as long as only one US was involved; 3) Inhibition did not transfer from the same CE to a new US (and CR); and, 4) Inhibition transferred from one CE to another in spite of the extinction of excitation controlled by the initial CE.

Rescorla and Holland (1977) and Rescorla (1973) suggest, then, that the site of inhibitory action is the US image. This is reflected in Figure 8. Here, Pavlovian conditioned inhibition training establishes connections between CI and US images such that the occurrence of CI raises the threshold for activation of the US image. The CI, then, has an effect only relative to activation of the US representation, by the US or by CE. When the CE is presented in compound with the CI, the CR is diminished because excitation of the US image must exceed the higher threshold established by CI.

Within this threshold notion of conditioned inhibition, nonreinforced presentations of a conditioned inhibitor should not diminish previously established inhibitory control. The presentation of the inhibitory stimulus evokes no competing response which would be discrepant from the

"null" outcome. Where there is no discrepancy, no learning takes place, so the conditioned inhibitor retains inhibitory control. Inhibition should be diminished only if the conditioned inhibitor is paired with the US, establishing excitatory connections between the (former) CI and US images.

Finally, it has been suggested that while Figure 8 may accurately describe the relationship between stimuli and responses following simultaneous compound conditioned inhibition training, it does not necessarily follow that identical relationships are established by way of other inhibitory paradigms. Different paradigms may establish inhibition via different mechanisms, e.g., at different sites (Rescorla, 1975; Rescorla & Holland, 1977).

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A P P E N D I X A:

Response Rates

Tables 7-39.

Comments on Tables:

These tables present the response rate data necessary to the computation of suppression ratios in Experiments 1-4. CS represents, in general, the number of responses during the CS; P-CS represents, in general, the number of responses during the interval immediately preceding, and equal in duration to, the CS. However, in Tables 36 and 37, the CS data for A represents an average of responses made during the two presentations of A per session. Further, P-CS data on Tables 36 and 37 were determined by dividing the total number of responses made during non-stimulus time (i.e., no stimuli occurring) by the amount of non-stimulus time over the entire session (in terms of CS-long intervals). That is, P-CS rates on Tables 36 and 37 are a function of overall responses (occurring in CS absence) during the 2-hr session rather than during specific pre-CS intervals.

Table 7: Experiment 1. Pre-CS and CS response rates on the last day of simultaneous compound conditioned inhibition training for Group E.

		Stimulus											
Subject		A	AX	A	AX	AX	A	A	AX	AX	A	AX	A
1	P-CS	14	15	11	10	13	12	7	7	11	7	8	10
	CS	14	16	7	18	18	9	4	13	10	4	7	3
2		21	21	22	18	17	9	10	6	6	3	5	6
		19	20	2	12	15	8	3	9	9	8	3	3
3		29	18	23	16	16	13	16	12	10	6	7	2
		1	26	2	24	20	3	2	11	5	4	7	2
4		12	8	7	6	5	11	9	8	5	3	2	2
		0	9	0	13	6	3	0	6	2	4	0	1
5		27	17	14	12	16	18	7	7	11	7	6	9
		0	13	0	19	10	1	0	6	14	6	7	3
6		12	13	11	9	9	9	10	9	8	6	4	5
		4	10	2	14	9	0	2	10	6	1	6	0
7		18	13	16	13	12	13	12	12	14	13	7	12
		2	17	2	16	14	2	8	14	16	1	15	5
8		20	17	30	33	26	12	14	19	10	12	8	10
		0	14	0	26	26	0	0	24	16	0	6	0

Table 8: Experiment 1. Pre-CS and CS response rates on the last day of simultaneous compound conditioned inhibition training for Group C.

		Stimulus											
Subject		A	AX	A	AX	AX	A	A	AX	AX	A	AX	A
1	P-CS	42	35	29	30	33	32	24	27	34	23	27	28
	CS	10	22	3	46	30	21	27	53	37	31	33	32
2		15	12	12	10	12	11	6	9	13	9	13	7
		1	17	1	20	15	2	4	14	14	2	16	4
3		5	5	11	14	5	6	5	11	7	4	4	2
		0	6	1	6	6	3	1	10	7	4	5	7
4		32	29	11	11	12	6	28	12	24	36	8	27
		5	27	3	25	21	3	11	12	28	12	23	19
5		23	18	24	18	15	24	28	21	30	23	23	32
		1	31	1	28	18	4	2	32	30	12	31	24
6		25	25	25	20	25	19	22	23	15	27	17	16
		8	35	3	21	19	0	9	18	17	7	22	13
7		17	16	17	20	12	14	17	9	12	10	15	15
		0	13	0	17	13	10	2	15	10	1	16	8
8		10	12	14	16	11	13	8	14	10	7	6	1
		0	5	0	4	4	2	1	10	22	0	8	5

Table 9: Experiment 1. Pre-CS and CS response rates on the last day of extinction for Group E.

Subject		Stimulus											
		AX	A	X	AX	A	X	AX	X	A	A	AX	X
1	P-CS	63	40	40	53	47	48	31	38	31	44	53	38
	CS	48	54	52	61	59	81	65	61	49	39	100	36
2		27	11	21	21	16	12	20	13	16	12	12	10
		18	16	21	15	17	20	20	20	12	14	14	10
3		28	40	35	30	28	32	25	21	15	18	27	12
		36	41	30	28	27	38	19	22	18	14	15	15
4		14	12	13	19	8	8	10	7	5	7	8	5
		15	13	12	13	14	17	8	11	1	5	12	10
5		88	39	27	25	12	15	28	29	14	45	68	49
		56	37	23	20	19	48	52	27	25	76	102	22
6		28	12	15	15	12	12	14	6	11	11	7	8
		22	13	23	14	13	16	16	12	9	11	16	14
7		11	15	17	15	16	13	11	13	14	14	15	9
		19	8	17	19	14	21	19	8	18	19	19	11
8		25	32	41	25	34	26	20	25	22	25	30	15
		30	23	53	46	11	34	41	55	21	27	30	33

Table 10: Experiment 1. Pre-CS and CS response rates on Day 1 of conditioned inhibition savings test for Group E.

		Stimulus											
Subject		BX	B	B	BX	B	BX	BX	B	BX	B	B	BX
1	P-CS	29	38	27	28	14	40	34	39	22	37	15	14
	CS	16	22	9	20	6	26	16	8	15	5	3	8
2		10	16	20	18	19	19	19	9	10	13	7	9
		14	18	7	22	9	25	26	1	16	0	3	10
3		36	37	19	22	18	14	11	19	14	18	9	6
		12	5	0	16	0	16	22	1	15	0	0	8
4		12	6	6	8	6	10	7	9	8	12	7	6
		2	0	0	0	0	0	3	0	1	0	1	2
5		28	14	38	19	19	14	10	19	10	16	9	24
		19	35	1	12	1	5	4	1	22	0	0	15
6		17	12	13	12	12	11	10	10	9	10	9	7
		9	6	1	7	0	11	12	3	10	3	1	8
7		16	14	15	17	13	15	14	17	11	10	11	12
		15	15	7	22	3	16	20	0	13	2	2	13
8		30	40	29	47	33	32	46	41	21	21	21	22
		36	34	5	35	0	56	69	1	57	1	2	36

Table 11: Experiment 1. Pre-CS and CS response rates on Day 1 of conditioned inhibition savings test for Group C.

		Stimulus											
Subject		BX	B	B	BX	B	BX	BX	B	BX	B	B	BX
1	P-CS	22	19	18	16	16	12	15	15	15	14	9	9
	CS	18	12	5	10	8	15	14	13	13	7	9	13
2		13	8	11	5	9	4	8	9	7	8	10	6
		9	4	1	16	2	17	11	1	19	0	2	11
3		22	7	9	1	5	2	5	2	14	1	3	8
		0	0	0	0	0	1	1	2	7	1	0	0
4		12	4	7	4	14	15	8	17	9	6	6	8
		19	14	6	17	8	24	19	3	12	8	19	8
5		46	22	23	12	3	16	20	30	18	34	20	17
		8	0	0	5	0	19	30	4	40	2	2	41
6		28	19	8	12	20	17	19	14	17	14	11	17
		25	18	14	34	24	32	24	18	33	1	1	20
7		24	16	15	17	19	21	24	24	23	19	20	6
		21	11	9	22	0	21	16	22	18	1	0	27
8		15	11	9	10	9	9	6	7	6	5	6	2
		0	0	0	1	0	0	3	0	0	0	0	0

Table 12: Experiment 1. Pre-CS and CS response rates on Day 2 of conditioned inhibition savings test for Group E.

		Stimulus											
Subject		B	BX	B	BX	BX	B	B	BX	BX	B	BX	B
1	P-CS	44	40	54	79	55	48	32	49	50	27	42	12
	CS	6	34	12	68	23	7	19	46	28	8	38	11
2		19	12	16	16	20	20	19	9	13	9	7	7
		3	28	6	23	30	3	2	8	19	2	17	0
3		30	35	20	16	14	23	11	13	19	6	14	7
		1	38	0	30	28	0	3	27	24	4	19	22
4		8	3	4	6	4	2	1	4	5	5	3	0
		0	12	1	6	14	0	0	6	9	0	14	0
5		38	11	10	18	54	48	15	15	21	11	44	13
		1	32	1	32	36	1	0	60	31	1	70	0
6		16	15	11	9	10	11	10	9	9	7	9	7
		1	14	2	10	2	1	0	9	9	1	3	0
7		12	14	15	16	11	17	18	15	18	14	17	8
		4	20	6	20	16	3	3	19	20	5	21	3
8		37	34	15	33	32	23	23	19	23	24	15	20
		1	17	0	56	55	0	0	42	39	0	54	0

Table 13: Experiment 1. Pre-CS and CS response rates on Day 2 of conditioned inhibition savings test for Group C.

		Stimulus											
Subject		B	BX	B	BX	BX	B	B	BX	BX	B	BX	B
1	P-CS	16	14	15	15	19	15	12	16	13	15	10	9
	CS	11	20	14	23	21	8	7	16	8	8	19	5
2		12	13	13	9	11	10	10	11	8	9	12	15
		2	21	3	20	14	2	1	22	15	2	18	1
3		18	19	12	10	7	5	2	4	5	4	6	3
		0	0	1	2	17	4	1	15	34	3	15	1
4		17	3	14	7	9	23	17	24	9	28	17	26
		2	12	14	41	15	8	9	22	19	12	9	21
5		40	5	12	1	27	29	4	4	22	19	35	25
		1	34	1	37	32	3	1	27	45	1	47	5
6		34	28	34	24	16	19	24	29	17	17	21	24
		2	11	0	46	33	2	4	35	41	1	24	2
7		19	17	14	12	25	14	13	14	21	15	12	14
		0	19	0	12	23	6	0	15	26	17	18	6
8		13	10	10	9	8	11	8	4	4	4	3	2
		0	0	0	7	3	0	0	4	1	0	3	0

Table 14: Experiment 1. Pre-CS and CS response rates on Day 3 of conditioned inhibition savings test for Group E.

		Stimulus											
Subject		BX	B	BX	B	B	BX	B	BX	B	BX	BX	B
1	P-CS	52	50	36	48	63	46	62	41	60	45	63	27
	CS	65	45	37	23	8	74	24	57	15	54	53	11
2		10	15	11	15	12	14	14	11	13	4	4	7
		26	2	21	6	5	19	6	11	3	11	4	0
3		32	19	26	15	23	15	14	8	9	8	5	5
		47	6	23	1	1	27	1	18	0	6	9	0
4		7	5	8	3	7	5	8	3	4	4	4	5
		10	1	15	2	1	9	0	9	1	6	4	0
5		78	10	43	16	48	19	40	33	21	44	17	21
		78	0	24	0	0	27	1	45	4	31	42	5
6		15	12	12	10	10	13	9	9	9	7	7	6
		18	11	11	1	1	10	2	13	2	14	6	0
7		18	12	12	11	15	16	14	16	16	18	17	11
		16	12	17	1	1	16	3	18	3	18	19	1
8		32	39	30	26	29	26	26	29	30	25	13	12
		51	0	61	0	0	67	0	59	0	22	35	3

Table 15: Experiment 1. Pre-CS and CS response rates on Day 3 of conditioned inhibition savings test for Group C.

		Stimulus											
Subject		BX	B	BX	B	B	BX	B	BX	B	BX	BX	B
1	P-CS	17	13	15	15	15	14	15	13	14	9	7	11
	CS	20	10	20	15	10	21	12	17	10	4	9	9
2		17	13	12	9	10	8	6	15	6	11	3	8
		21	2	20	4	4	19	6	16	3	20	18	4
3		17	7	16	5	15	2	12	2	17	5	1	3
		23	5	29	10	10	51	41	35	12	27	18	3
4		13	17	11	16	5	12	9	25	7	18	20	8
		33	26	38	5	9	67	5	71	7	59	49	18
5		22	5	10	8	34	7	18	17	24	36	23	34
		28	2	33	9	10	46	6	48	5	42	47	11
6		46	35	23	35	29	24	11	22	17	22	19	19
		34	6	42	4	5	24	9	23	16	30	29	9
7		10	16	12	16	11	6	16	14	25	16	14	21
		23	15	18	3	2	24	3	28	6	18	29	4
8		11	11	7	6	5	4	7	3	3	6	1	0
		8	1	7	0	0	6	0	5	0	7	0	0

Table 16: Experiment 1. Pre-CS and CS response rates on Day 4 of conditioned inhibition savings test for Group E.

		Stimulus											
Subject		BX	B	B	BX	B	BX	BX	B	BX	B	B	BX
1	P-CS	28	57	73	46	78	60	49	44	49	65	53	12
	CS	59	26	31	47	21	45	51	23	60	20	42	20
2		15	14	17	11	16	14	19	18	12	11	14	15
		17	2	4	14	12	14	16	2	12	1	1	6
3		29	37	25	25	25	34	30	32	22	25	8	9
		39	2	0	34	1	32	27	2	22	0	2	13
4		5	14	10	8	10	8	9	5	7	10	0	11
		15	2	0	20	2	14	14	1	9	0	2	4
5		73	64	28	24	89	56	49	37	59	91	44	38
		46	0	2	26	22	42	29	6	20	6	15	10
6		11	11	14	10	14	11	13	10	18	9	5	11
		18	0	0	9	2	14	11	0	16	7	2	9
7		17	19	19	17	17	20	18	20	19	18	13	9
		21	2	4	21	2	19	20	10	22	1	3	18
8		36	34	35	33	33	32	29	31	39	31	30	27
		44	0	0	70	0	46	41	1	51	1	4	52

Table 17: Experiment 1. Pre-CS and CS response rates on Day 4 of conditioned inhibition savings test for Group C.

		Stimulus											
Subject		BX	B	B	BX	B	BX	BX	B	BX	B	B	BX
1	P-CS	18	17	20	20	20	18	19	16	14	16	10	8
	CS	21	14	16	20	16	23	15	13	16	8	11	9
2		19	15	8	13	14	14	16	8	6	12	7	15
		28	3	4	22	7	25	20	7	21	6	5	17
3		12	14	3	9	5	9	2	4	4	6	3	4
		26	21	11	17	12	12	16	6	27	10	4	2
4		28	14	20	9	27	10	33	5	37	7	6	17
		54	15	13	30	25	44	70	28	61	32	59	89
5		28	30	24	18	29	33	25	38	33	42	33	16
		41	5	5	40	11	47	51	18	48	9	13	31
6		50	41	48	18	25	15	22	18	24	15	14	15
		56	7	15	38	17	37	44	15	37	11	10	35
7		17	20	22	20	25	21	36	19	28	19	26	12
		26	3	21	26	14	40	40	28	24	3	16	15
8		18	15	7	12	7	8	9	4	7	8	4	7
		19	0	0	17	0	23	22	23	31	0	0	23

Table 18: Experiment 2. Pre-CS and CS response rates on Day 44 of simultaneous compound conditioned inhibition training for Group E.

		Stimulus											
Subject		A	AX	AX	A	A	AX	A	AX	AX	A	AX	A
1	P-CS	5	5	6	4	6	2	2	6	9	3	9	7
	CS	2	9	6	3	2	8	1	13	8	3	7	2
2		37	13	30	8	9	23	2	8	15	2	15	4
		0	39	20	3	5	20	11	45	19	0	0	4
3		45	38	24	30	17	15	5	16	23	8	11	12
		3	25	18	2	1	13	0	27	12	2	5	1
4		12	6	12	5	8	9	6	11	9	4	5	9
		0	10	10	2	3	8	4	10	7	7	7	2
5		17	20	20	14	21	8	15	11	21	7	11	16
		21	12	19	4	13	10	6	27	18	4	8	5
6		5	5	5	5	6	3	6	3	6	4	4	4
		2	5	7	2	2	7	1	9	3	2	5	4
7		10	7	10	8	6	11	9	9	10	8	7	7
		0	12	14	0	0	8	0	16	4	0	9	1

Table 19: Experiment 2. Pre-CS and CS response rates on Day 44 of simultaneous compound conditioned inhibition training for Group C.

		Stimulus											
Subject		A	AX	AX	A	A	AX	A	AX	AX	A	AX	A
1	P-CS	26	23	19	15	16	14	7	12	4	6	18	6
	CS	1	7	8	0	1	12	1	3	6	0	0	0
2		11	8	11	9	7	8	7	4	7	9	7	6
		1	10	10	1	1	7	0	6	0	0	8	1
3		6	12	9	13	11	14	15	9	16	12	6	9
		1	2	8	4	2	4	5	5	7	1	3	3
4		27	12	14	10	14	12	13	3	10	10	12	14
		3	22	17	2	4	14	5	19	12	8	9	9
5		6	6	8	12	8	4	7	1	5	6	4	0
		0	0	1	0	0	2	0	3	1	0	1	0
6		9	7	10	6	9	6	5	3	6	6	2	5
		1	11	13	1	1	6	0	8	7	0	11	1
7		11	11	10	12	6	8	6	4	12	10	14	8
		0	14	13	0	2	2	2	11	20	1	6	0

Table 20: Experiment 2. Pre-CS and CS response rates on Day 45 of simultaneous compound conditioned inhibition training for Group E.

		Stimulus											
Subject		A	AX	A	AX	AX	A	A	AX	AX	A	A	AX
1	P-CS	14	13	3	15	2	12	10	13	7	6	1	3
	CS	7	6	1	12	6	2	2	11	6	2	3	10
2		34	16	16	10	10	29	12	2	3	9	4	9
		1	39	14	20	30	0	1	26	33	6	1	18
3		31	26	26	30	19	40	20	21	14	13	1	6
		5	26	6	15	21	2	5	26	14	1	0	6
4		10	15	13	13	12	8	6	6	10	7	7	9
		2	6	3	11	8	3	4	8	4	1	1	5
5		23	19	13	7	17	15	22	14	10	11	14	11
		8	26	5	22	10	2	5	13	5	1	1	13
6		6	5	6	6	4	7	8	9	4	4	5	3
		5	5	3	8	6	2	4	6	9	2	2	4
7		8	6	4	6	6	13	14	8	10	6	3	6
		0	10	0	6	13	0	1	11	9	0	9	4

Table 21: Experiment 2. Pre-CS and CS response rates on Day 45 of simultaneous compound conditioned inhibition training for Group C.

		Stimulus											
Subject		A	AX	A	AX	AX	A	A	AX	AX	A	A	AX
1	P-CS	12	20	12	17	14	21	15	7	12	10	9	6
	CS	0	20	1	16	24	0	3	8	4	1	1	7
2		12	12	10	9	6	6	6	5	6	8	2	7
		1	10	1	7	6	1	0	7	6	1	0	5
3		14	15	6	7	8	10	13	11	7	12	8	13
		0	2	2	3	3	3	2	4	3	1	2	5
4		28	14	12	15	13	11	11	10	8	5	8	12
		7	23	7	13	13	1	0	13	20	10	7	13
5		9	3	4	9	5	4	1	7	4	0	2	2
		0	0	0	2	2	0	0	4	1	0	0	1
6		7	9	9	11	8	7	8	4	9	9	9	3
		0	11	1	7	11	0	1	13	9	1	0	10
7		10	21	15	20	17	14	11	7	7	11	9	6
		1	25	0	17	10	3	0	16	5	0	4	9

Table 22: Experiment 2. Pre-CS and CS response rates on Day 46 of simultaneous compound conditioned inhibition training for Group E.

		Stimulus											
Subject		AX	A	A	AX	AX	A	A	AX	A	AX	AX	A
1	P-CS	16	7	9	14	10	9	5	7	3	6	4	4
	CS	6	4	8	6	4	8	3	8	1	9	7	4
2		25	24	17	16	13	8	8	3	5	6	2	3
		28	0	1	17	10	7	0	8	3	8	5	2
3		34	43	51	22	29	18	20	15	2	9	12	10
		31	4	0	24	15	0	6	23	0	7	15	6
4		8	8	8	9	9	10	14	4	4	8	5	4
		2	1	3	9	10	2	3	5	2	7	5	5
5		10	19	7	2	12	4	5	9	2	16	2	11
		6	8	4	20	8	0	2	15	3	16	5	6
6		6	4	7	6	6	4	5	5	6	5	4	5
		6	2	1	6	6	3	3	6	4	6	7	1
7		9	11	12	10	10	15	7	6	6	11	6	6
		9	0	4	12	14	0	0	12	0	7	10	0

Table 23: Experiment 2. Pre-CS and CS response rates on Day 46 of simultaneous compound conditioned inhibition training for Group C.

		Stimulus											
Subject		AX	A	A	AX	AX	A	A	AX	A	AX	AX	A
1	P-CS	7	17	11	13	13	17	10	6	13	13	9	9
	CS	0	2	0	17	9	2	1	7	2	6	6	3
2		9	9	10	7	8	8	5	7	9	6	11	10
		10	0	1	6	10	1	0	7	2	8	9	0
3		10	19	8	9	11	18	10	12	12	15	6	13
		8	4	1	4	4	0	2	10	0	9	5	3
4		18	11	14	12	12	13	9	13	8	4	14	9
		20	2	8	5	7	4	3	17	3	12	11	8
5		8	7	8	1	6	1	6	4	1	0	4	4
		0	0	0	0	1	1	0	0	0	0	2	0
6		8	8	12	5	7	7	10	6	4	5	4	8
		15	1	0	11	12	0	0	10	0	15	18	1
7		21	15	6	14	18	19	2	14	0	9	9	15
		14	2	0	16	26	0	0	12	0	26	14	1

Table 24: Experiment 2. Pre-CS and CS response rates on the last day of extinction for Group E.

		Stimulus											
Subject		A	AX	X	AX	X	A	A	X	AX	A	X	AX
1	P-CS	5	12	10	9	1	8	4	5	9	5	6	3
	CS	5	13	16	7	10	11	7	9	5	9	5	8
2		43	42	23	15	44	35	1	25	8	22	10	1
		52	46	26	44	33	28	12	36	32	8	7	5
3		30	35	33	26	22	2	17	12	5	24	6	7
		8	38	16	19	32	4	9	29	30	32	5	9
4		16	23	21	30	10	28	22	17	6	8	8	13
		12	6	44	21	12	8	8	12	7	6	18	13
5		8	10	27	6	0	4	10	13	9	12	9	2
		14	21	42	19	27	23	11	19	22	14	14	14
6		4	11	5	7	5	10	5	6	2	3	3	8
		8	6	6	10	4	2	6	5	6	6	6	1
7		7	17	9	7	5	11	10	10	7	13	9	3
		5	18	15	8	9	13	10	14	9	10	5	6

Table 25: Experiment 2. Pre-CS and CS response rates during summation testing for Group E.

		Stimulus					
Subject		BX	B	BX	B	B	BX
1	P-CS	10	10	13	3	5	3
	CS	2	4	16	6	9	6
2		51	31	10	6	5	5
		0	1	18	1	11	5
3		23	24	4	20	5	10
		1	0	18	15	12	15
4		18	14	13	9	9	9
		1	4	17	11	9	18
5		10	10	6	15	14	5
		14	9	14	17	14	10
6		7	4	3	2	7	6
		0	7	1	4	4	3
7		2	5	4	8	4	2
		10	4	15	4	3	6

Table 26: Experiment 2. Pre-CS and CS response rates during summation testing for Group C.

		Stimulus					
Subject		BX	B	BX	B	B	BX
1	P-CS	13	16	14	10	16	11
	CS	1	1	0	6	5	14
2		12	11	6	8	5	7
		0	1	0	1	9	0
3		9	7	6	6	10	7
		0	12	10	11	15	11
4		13	22	8	14	3	7
		1	20	9	18	8	10
5		7	15	5	3	8	5
		2	7	11	13	10	8
6		10	7	11	6	9	6
		0	1	2	0	0	8
7		20	16	5	8	7	5
		0	0	16	0	0	13

Table 27: Experiment 2. Pre-CS and CS response rates on Day 1 of retardation testing for Group E.

		Stimulus			
Subject		X	X	X	X
1	P-CS	13	6	3	13
	CS	14	9	5	5
2		35	20	6	3
		32	1	22	0
3		39	0	10	3
		34	39	7	7
4		17	10	6	5
		25	18	8	9
5		20	8	4	7
		30	33	5	8
6		4	3	7	5
		7	3	5	7
7		6	6	7	9
		12	8	9	12

Table 28: Experiment 2. Pre-CS and CS response rates on Day 1 of retardation testing for Group C.

		Stimulus			
Subject		X	X	X	X
1	P-CS	9	15	2	20
	CS	17	1	0	0
2		9	5	10	3
		8	0	0	0
3		10	8	6	6
		13	0	8	0
4		13	17	7	39
		9	6	5	6
5		15	11	2	5
		10	5	3	0
6		8	10	5	7
		11	1	3	0
7		33	18	12	7
		17	1	16	0

Table 29: Experiment 2. Pre-CS and CS response rates on Day 2 of retardation testing for Group E.

		Stimulus			
Subject		X	X	X	X
1	P-CS	12	3	17	6
	CS	2	0	1	4
2		34	20	1	4
		4	0	0	0
3		45	25	9	12
		0	0	1	4
4		31	7	21	23
		0	3	0	2
5		10	17	16	7
		28	19	6	15
6		5	4	8	3
		3	3	5	2
7		4	5	8	11
		3	5	2	12

Table 30: Experiment 2. Pre-CS and CS response rates on Day 2 of retardation testing for Group C.

		Stimulus			
Subject		X	X	X	X
1	P-CS	15	14	6	13
	CS	0	0	0	0
2		9	10	6	6
		0	0	0	0
3		4	6	4	15
		0	0	0	0
4		22	7	7	5
		1	1	0	0
5		9	5	5	3
		0	4	4	0
6		13	7	9	3
		0	0	0	0
7		18	9	6	8
		0	0	0	0

Table 31: Experiment 3. Pre-CS and CS response rates on the last day of simultaneous compound conditioned inhibition training for Group C.

		Stimulus											
Subject		AX	A	A	AX	AX	A	A	AX	A	AX	AX	A
1	P-CS	23	14	17	14	8	9	9	12	7	8	8	8
	CS	17	3	0	13	10	0	0	12	2	14	12	1
2		10	17	12	10	12	12	11	15	10	12	13	9
		9	0	0	16	10	0	0	10	0	20	14	0
3		8	2	0	3	1	2	6	2	3	1	2	3
		6	4	0	4	2	0	0	2	0	3	4	0
4		4	7	9	6	5	6	6	4	3	9	7	7
		9	1	0	5	5	0	0	8	0	20	13	0
5		11	13	14	11	9	11	10	12	12	8	8	10
		12	0	2	10	13	0	1	13	0	15	6	0
6		16	11	19	13	8	8	6	10	9	7	7	12
		8	1	3	12	13	2	1	16	1	9	10	0
7		4	4	6	4	5	4	3	7	6	8	5	9
		6	0	0	6	10	2	2	5	2	12	6	0

Table 32: Experiment 3. Pre-CS and CS response rates on the last day of simultaneous compound conditioned inhibition training for Group F.

		Stimulus											
Subject		AX	A	A	AX	AX	A	A	AX	A	AX	AX	A
1	P-CS	6	8	8	6	6	5	6	6	6	9	8	9
	CS	5	1	0	5	9	0	0	10	0	11	9	0
2		8	13	4	11	3	11	8	3	8	2	2	3
		6	1	1	6	11	2	0	13	2	14	11	1
3		18	4	4	4	2	16	6	14	7	4	11	1
		6	3	2	5	7	0	0	8	2	13	7	0
4		10	13	8	8	8	6	7	3	5	3	4	6
		15	0	0	10	13	0	0	10	0	15	6	0
5		8	7	6	3	6	7	7	2	4	6	8	5
		0	0	0	0	0	0	0	6	0	8	5	1
6		10	9	7	10	11	7	7	6	5	5	6	5
		7	1	0	10	8	1	0	9	1	10	8	1
7		38	18	17	14	14	14	20	8	16	10	24	10
		30	9	1	23	13	2	2	15	2	16	24	3
8		6	4	4	4	5	6	3	9	8	4	7	7
		3	0	1	12	14	1	1	16	0	13	13	0

Table 33: Experiment 3. Pre-CS and CS response rates during summation testing for Group C.

		Stimulus					
Subject		AX	A	AX	A	A	AX
1	P-CS	15	17	33	17	15	17
	CS	16	1	25	17	22	16
2		22	24	24	12	23	27
		20	0	18	18	14	22
3		6	10	10	5	3	3
		0	0	6	2	8	9
4		7	7	7	6	8	9
		5	0	9	0	1	6
5		13	10	11	10	13	14
		4	0	9	11	11	11
6		18	18	15	11	14	12
		10	0	14	0	7	17
7		4	5	7	3	1	2
		0	0	7	3	4	5

Table 34: Experiment 3. Pre-CS and CS response rates during summation testing for Group F.

		Stimulus					
Subject		AX	A	AX	A	A	AX
1	P-CS	10	7	7	4	10	7
	CS	0	0	3	0	2	7
2		8	4	5	4	4	4
		0	0	4	7	7	1
3		8	8	8	1	9	9
		0	0	9	0	5	19
4		10	12	7	6	6	9
		0	0	5	2	0	8
5		10	7	5	7	10	3
		0	0	4	0	0	10
6		11	8	4	3	6	7
		0	0	10	4	3	8
7		14	7	9	11	14	15
		0	0	12	3	6	13
8		7	3	2	3	6	4
		0	0	5	1	1	10

Table 35: Experiment 4. Pre-CS and CS response rates on the last day of simultaneous compound conditioned inhibition training for Group E.

Subgroup	Subject		Stimulus AY	A	AX	AX	AY	A	AX	AY	A	A	AX	AY
E-L	1	P-CS	18	9	7	16	10	10	7	5	3	3	6	1
		CS	19	2	9	12	12	2	5	6	1	0	8	13
	2		1	5	9	10	9	8	8	7	11	11	8	13
			7	0	6	1	3	0	8	4	0	0	4	3
	3		15	13	16	15	11	10	15	7	6	4	8	5
			22	11	16	18	24	2	18	17	12	4	14	15
	4		71	45	66	20	38	23	33	23	17	28	24	10
			54	7	74	51	67	3	29	59	0	0	63	68
E-T	1		19	13	14	14	22	15	16	18	23	20	14	11
			23	2	16	13	17	1	17	18	2	1	21	22
	2		5	11	11	10	7	9	8	7	10	8	8	7
			15	4	6	9	9	7	5	11	1	2	2	13
	3		9	9	7	9	10	3	9	8	10	9	6	0
			10	5	8	10	10	0	7	8	1	2	4	7

Table 36: Experiment 4. Pre-CS and CS response rates on Probe and A (average of 2) trials on the 8 days of truly random training for Group E.

Subgrp.	Subject		Day 1 AY/A	2 AX/A	3 AY/A	4 AX/A	5 AY/A	6 AX/A	7 AY/A	8 AX/A
E-L	1	P-CS*	6.4	6.6	4.4	6.3	6.3	7.8	8.3	10.0
		CS	0/0.5	4/0.5	11/4	1/2	4/1.5	3/7	14/4.5	18/3
	2		5.6	5.1	5.0	3.8	5.1	5.0	4.7	4.1
			1/0.5	0/0	12/1.5	0/0	8/0	0/3	11/0	3/0.5
	3		8.8	8.5	6.6	7.8	6.8	5.9	7.0	5.8
			9/2.0	3/0.5	11/1	5/4.5	10/1.5	6/4	10/2.5	8/3
	4		22	13.6	8.4	5.2	7.6	5.1	7.6	6.0
			40/1	1/1	12/3	0/0.5	11/0.5	2/0	33/0	3/0.5
E-T	1		12.2	12.3	11.6	7.9	7.8	5.8	7.2	**
			17/0.5	0/0.5	20/1	0/0	17/1.5	6/0	17/0.5	**
	2		6.0	2.4	2.7	3.5	2.1	2.0	2.0	2.2
			9/1.0	0/0	5/0.5	2/0	9/0	2/0	4/1	1/1.5
	3		8.6	7.8	2.6	4.0	4.6	2.3	5.2	3.9
			12/7	4/1	22/1.5	3/2	9/2.5	4/0	8/3	9/4.5

*Pre-CS rate is an average of responding during non-stimulus time in the total session.

**Data lost due to equipment failure.

Table 37: Experiment 4. Pre-CS and CS response rates on Probe and A (average of 2) trials on the 8 days of truly random training for Group N.

Subgrp.	Subject		Day 1 AY/A	2 AX/A	3 AY/A	4 AX/A	5 AY/A	6 AX/A	7 AY/A	8 AX/A
N-L	1	P-CS*	5.8	4.5	5.0	4.6	1.2	2.2	2.1	2.6
		CS	0/0	0/0	0/0	0/1	0/0.5	2/0.5	0/1	0/0
	2		8.1	5.9	2.9	5.5	1.6	5.4	5.9	4.9
			0/1.5	0/0	0/0	0/1.5	2/0.5	0/0	14/0	0/0.5
	3		8.8	7.4	4.8	5.0	5.8	4.6	4.6	3.3
			0/2	0/0.5	1/1.5	4/2.5	0/3.5	3/0	2/0	0/1.5
	4		1.2	0.0	0.0	1.4	5.1	4.5	5.1	3.1
			0/0	0/0	0/0	0/0	2/0	0/1	3/0	0/0.5
N-T	1		8.2	5.5	2.9	3.2	4.3	2.4	2.9	**
			3/0	0/0.5	1/0.5	0/0	0/0.5	0/0	4/0	**
	2		5.9	5.2	7.7	8.4	7.8	7.8	9.3	**
			7/2	0/0.5	12/3.5	6/7	7/4	3/4	19/6	**
	3		10.7	10.2	2.2	11.0	9.4	10.2	13.8	10.5
			0/0	0/0	0/0.5	0/0	0/0	0/0	0/1	0/0
	4		23.8	5.2	16.6	5.0	13.3	2.0	10.0	14.0
			5/0.5	0/0	15/0.5	0/0	6/0	0/0	0/1	0/0

*Pre-CS rate is an average of responding during non-stimulus time in the total session.

**Data lost due to equipment failure.

Table 38: Experiment 4. Pre-CS and CS response rates during summation testing for Group E.

			Stimulus					
Subgroup	Subject		AX	AY	A	AY	A	AX
E-L	1	P-CS	28	9	11	3	4	9
		CS	12	11	6	11	6	14
	2		7	6	4	5	6	7
			0	6	0	13	1	2
	3		6	10	8	11	4	11
			2	9	6	13	6	19
	4		16	18	43	14	11	4
			1	41	0	15	0	36
E-T	1		13	4	2	3	7	8
			0	8	0	20	1	5
	2		8	7	4	5	8	7
			0	12	0	11	0	1
	3		6	6	9	10	5	7
			0	10	1	7	1	5

Table 39: Experiment 4. Pre-CS and CS response rates during summation testing for Group N.

			Stimulus					
Subgroup	Subject		AX	AY	A	AY	A	AX
N-L	1	P-CS	8	6	6	7	8	5
		CS	0	1	0	0	0	0
	2		6	7	11	9	7	5
			0	10	0	7	4	1
	3		10	14	7	13	4	9
			0	4	7	17	9	2
	4		6	5	6	2	2	1
			0	3	1	7	0	0
N-T	1		15	11	9	6	11	3
			0	7	0	23	0	0
	2		16	8	7	13	8	16
			1	7	7	16	3	5
	3		31	21	34	29	4	7
			0	0	0	0	0	0
	4		31	35	14	17	24	17
			0	10	1	1	0	0

A P P E N D I X B:

Suppression Ratios

Tables 40-58.

Comments on Tables:

These tables present suppression ratio data for Experiments 1-4. Conditioned suppression to stimulus presentations was measured by forming a ratio of the form A/A+B, where A denotes the number of responses during the CS (CS on the tables in Appendix A) and B the responses in the pre-CS interval (P-CS on the tables in Appendix A)(Annau & Kamin, 1961).

Where an animal failed to respond in the pre-CS interval, no suppression ratio was figured.

Table 40: Experiment 1. Suppression ratios on the last day of simultaneous compound conditioned inhibition training for Groups E and C.

Group	Subject	Stimulus											
		A	AX	A	AX	AX	A	A	AX	AX	A	AX	A
E	1	.50	.52	.39	.64	.58	.43	.36	.65	.48	.36	.47	.23
	2	.48	.49	.08	.40	.47	.47	.23	.60	.60	.73	.38	.33
	3	.03	.59	.08	.60	.56	.19	.11	.49	.33	.40	.50	.50
	4	.00	.53	.00	.68	.55	.21	.00	.43	.29	.57	.00	.33
	5	.00	.43	.00	.61	.38	.05	.00	.46	.56	.46	.54	.25
	6	.25	.43	.13	.61	.50	.00	.17	.53	.43	.14	.60	.00
	7	.10	.57	.11	.55	.54	.13	.40	.54	.53	.07	.68	.29
	8	.00	.45	.00	.44	.50	.00	.00	.56	.62	.00	.53	.00
C	1	.19	.39	.09	.61	.48	.40	.53	.66	.52	.57	.55	.53
	2	.06	.59	.08	.67	.56	.15	.40	.61	.52	.18	.55	.36
	3	.00	.55	.08	.30	.55	.33	.17	.48	.50	.50	.56	.78
	4	.14	.48	.21	.69	.64	.33	.28	.50	.54	.25	.74	.41
	5	.04	.63	.04	.61	.55	.14	.07	.60	.50	.34	.57	.43
	6	.24	.58	.11	.51	.43	.00	.29	.44	.53	.21	.56	.45
	7	.00	.45	.00	.46	.52	.42	.11	.62	.45	.09	.52	.35
	8	.00	.29	.00	.20	.27	.13	.11	.42	.69	.00	.57	.83

Table 41: Experiment 1. Suppression ratios on the last day of extinction for Group E.

	Stimulus											
Subject	AX	A	X	AX	A	X	AX	X	A	A	AX	X
1	.43	.57	.57	.54	.56	.63	.68	.62	.61	.47	.65	.49
2	.40	.59	.50	.42	.52	.62	.50	.61	.43	.54	.54	.50
3	.56	.51	.46	.48	.49	.54	.43	.51	.55	.44	.36	.56
4	.52	.52	.48	.41	.64	.68	.44	.61	.17	.42	.60	.67
5	.39	.49	.46	.44	.61	.76	.65	.48	.64	.63	.60	.31
6	.44	.52	.61	.48	.52	.57	.53	.67	.45	.50	.70	.64
7	.63	.35	.50	.56	.47	.62	.63	.38	.56	.58	.56	.55
8	.55	.42	.56	.65	.24	.57	.67	.69	.49	.52	.50	.69

Table 42: Experiment 1. Suppression ratios on Day 1 of conditioned inhibition savings test for Groups E and C.

Group	Subject	Stimulus											
		BX	B	B	BX	B	BX	BX	B	BX	B	B	BX
E	1	.36	.37	.25	.42	.30	.39	.32	.17	.41	.12	.17	.36
	2	.58	.53	.26	.55	.32	.57	.58	.10	.62	.00	.30	.53
	3	.25	.12	.00	.42	.00	.53	.67	.05	.52	.00	.00	.57
	4	.14	.00	.00	.00	.00	.00	.30	.00	.11	.00	.12	.25
	5	.40	.71	.03	.39	.05	.26	.29	.05	.69	.00	.00	.38
	6	.35	.33	.07	.37	.00	.50	.55	.23	.53	.23	.10	.53
	7	.48	.52	.32	.56	.19	.52	.59	.00	.54	.17	.15	.52
	8	.55	.46	.15	.43	.00	.64	.60	.02	.73	.05	.09	.62
C	1	.45	.39	.22	.38	.33	.56	.48	.46	.46	.33	.50	.59
	2	.41	.33	.08	.76	.18	.81	.58	.10	.73	.00	.17	.65
	3	.00	.00	.00	.00	.00	.33	.17	.50	.33	.50	.00	.00
	4	.61	.78	.46	.81	.36	.62	.70	.15	.57	.57	.76	.50
	5	.15	.00	.00	.29	.00	.54	.60	.12	.69	.06	.09	.71
	6	.47	.49	.64	.74	.55	.65	.56	.56	.66	.07	.08	.54
	7	.47	.41	.38	.56	.00	.50	.40	.48	.44	.05	.00	.82
	8	.00	.00	.00	.09	.00	.00	.33	.00	.00	.00	.00	.00

Table 43: Experiment 1. Suppression ratios on Day 2 of conditioned inhibition savings test for Groups E and C.

Group	Subject	Stimulus											
		B	BX	B	BX	BX	B	B	BX	BX	B	BX	B
E	1	.12	.46	.18	.46	.29	.13	.37	.48	.36	.23	.48	.48
	2	.14	.70	.27	.59	.60	.13	.09	.47	.59	.18	.71	.00
	3	.03	.52	.00	.65	.67	.00	.21	.68	.56	.40	.58	.76
	4	.00	.80	.20	.50	.78	.00	.00	.60	.64	.00	.82	*
	5	.03	.74	.09	.64	.40	.02	.00	.80	.60	.08	.61	.00
	6	.06	.48	.15	.53	.17	.08	.00	.50	.50	.12	.25	.00
	7	.25	.59	.29	.56	.59	.15	.14	.56	.53	.26	.55	.27
	8	.03	.33	.00	.63	.63	.00	.00	.69	.63	.00	.78	.00
C	1	.41	.59	.48	.40	.52	.35	.37	.50	.38	.35	.66	.36
	2	.14	.62	.19	.69	.56	.17	.09	.67	.65	.18	.60	.06
	3	.00	.00	.08	.17	.71	.44	.33	.79	.87	.43	.71	.25
	4	.11	.80	.50	.85	.62	.26	.35	.48	.68	.30	.35	.45
	5	.02	.87	.08	.97	.54	.09	.20	.87	.67	.05	.57	.17
	6	.06	.28	.00	.66	.67	.09	.14	.55	.71	.06	.53	.08
	7	.00	.53	.00	.50	.48	.30	.00	.52	.55	.53	.60	.30
	8	.00	.00	.00	.44	.27	.00	.00	.50	.20	.00	.50	.00

*no responses during pre-CS interval

Table 44: Experiment 1. Suppression ratios on Day 3 of conditioned inhibition savings test for Groups E and C.

Group	Subject	Stimulus BX	B	BX	B	B	BX	B	BX	B	BX	BX	B
E	1	.56	.47	.51	.32	.11	.62	.28	.58	.20	.55	.46	.29
	2	.72	.12	.66	.29	.29	.58	.30	.50	.19	.73	.50	.00
	3	.59	.24	.47	.06	.04	.64	.07	.69	.00	.43	.64	.00
	4	.59	.17	.65	.40	.12	.64	.00	.75	.20	.60	.50	.00
	5	.50	.00	.36	.00	.00	.59	.02	.58	.16	.41	.71	.19
	6	.55	.48	.48	.09	.09	.43	.18	.59	.18	.67	.46	.00
	7	.47	.50	.59	.08	.06	.50	.18	.53	.16	.50	.53	.08
	8	.61	.00	.67	.00	.00	.72	.00	.67	.00	.47	.73	.20
C	1	.54	.43	.57	.50	.40	.60	.44	.57	.42	.31	.56	.45
	2	.55	.13	.62	.31	.29	.70	.50	.52	.33	.65	.86	.33
	3	.58	.42	.64	.67	.40	.96	.77	.95	.41	.84	.95	.50
	4	.72	.60	.78	.24	.64	.85	.36	.74	.50	.77	.71	.69
	5	.56	.29	.77	.53	.23	.87	.25	.74	.17	.54	.67	.24
	6	.42	.15	.65	.10	.15	.50	.45	.51	.48	.58	.60	.32
	7	.70	.48	.60	.16	.15	.80	.16	.67	.19	.53	.67	.16
	8	.42	.08	.50	.00	.00	.60	.00	.62	.00	.54	.00	*

*no responses during pre-CS interval

Table 46: Experiment 2. Suppression ratios on Day 44 of simultaneous compound conditioned inhibition training for Groups E and C.

		Stimulus											
Group	Subject	A	AX	AX	A	A	AX	A	AX	AX	A	AX	A
E	1	.29	.64	.50	.43	.25	.80	.33	.68	.47	.50	.44	.22
	2	.00	.75	.40	.27	.38	.47	.85	.85	.56	.00	.00	.50
	3	.06	.40	.43	.06	.06	.46	.00	.63	.34	.20	.31	.08
	4	.00	.62	.45	.29	.27	.47	.40	.48	.44	.64	.58	.18
	5	.55	.38	.49	.22	.38	.56	.29	.71	.46	.36	.42	.24
	6	.29	.50	.58	.29	.25	.70	.14	.75	.33	.33	.56	.50
	7	.00	.63	.58	.00	.00	.42	.00	.64	.29	.00	.56	.12
C	1	.04	.23	.30	.00	.06	.46	.12	.20	.60	.00	.00	.00
	2	.08	.56	.48	.10	.12	.47	.00	.60	.00	.00	.53	.14
	3	.14	.14	.47	.24	.15	.22	.25	.36	.30	.08	.33	.25
	4	.10	.65	.55	.17	.22	.54	.28	.86	.55	.44	.43	.39
	5	.00	.00	.11	.00	.00	.33	.00	.75	.17	.00	.25	*
	6	.10	.61	.56	.14	.10	.50	.00	.73	.54	.00	.85	.17
	7	.00	.56	.57	.00	.25	.20	.25	.73	.62	.09	.30	.00

*no responses in pre-CS interval

Table 47: Experiment 2. Suppression ratios on Day 45 of simultaneous compound conditioned inhibition training for Groups E and C.

		Stimulus											
Group	Subject	A	AX	A	AX	AX	A	A	AX	AX	A	A	AX
E	1	.33	.32	.25	.44	.75	.14	.17	.46	.46	.25	.75	.77
	2	.03	.71	.47	.67	.75	.00	.08	.93	.92	.40	.20	.67
	3	.14	.50	.19	.33	.52	.05	.20	.55	.50	.07	.00	.50
	4	.17	.29	.19	.46	.40	.27	.40	.57	.29	.12	.12	.36
	5	.26	.58	.28	.76	.37	.12	.19	.48	.33	.08	.07	.54
	6	.45	.50	.33	.57	.60	.22	.33	.40	.69	.33	.29	.57
	7	.00	.62	.00	.50	.68	.00	.07	.59	.47	.00	.75	.40
C	1	.00	.50	.08	.48	.63	.00	.17	.53	.25	.09	.10	.54
	2	.08	.45	.09	.44	.50	.14	.00	.58	.50	.11	.00	.42
	3	.00	.12	.25	.30	.27	.23	.13	.27	.30	.08	.20	.28
	4	.20	.62	.37	.46	.50	.08	.00	.57	.71	.67	.47	.52
	5	.00	.00	.00	.18	.29	.00	.00	.36	.20	*	.00	.33
	6	.00	.55	.10	.39	.58	.00	.11	.76	.50	.10	.00	.77
	7	.09	.54	.00	.46	.37	.18	.00	.70	.42	.00	.31	.60

*no responses during pre-CS interval

Table 48: Experiment 2. Suppression ratios on Day 46 of simultaneous compound conditioned inhibition training for Groups E and C.

		Stimulus											
Group	Subject	AX	A	A	AX	AX	A	A	AX	A	AX	AX	A
E	1	.27	.36	.47	.30	.29	.47	.38	.53	.25	.60	.64	.50
	2	.53	.00	.06	.52	.43	.47	.00	.73	.38	.57	.71	.40
	3	.48	.07	.00	.52	.34	.00	.23	.61	.00	.44	.46	.38
	4	.20	.11	.27	.50	.53	.17	.18	.56	.33	.47	.50	.56
	5	.38	.30	.36	.91	.40	.00	.29	.62	.60	.50	.71	.35
	6	.50	.33	.12	.50	.50	.43	.38	.55	.40	.55	.64	.17
	7	.50	.00	.25	.55	.58	.00	.00	.67	.00	.39	.62	.00
C	1	.00	.11	.00	.57	.41	.11	.09	.54	.13	.32	.40	.25
	2	.53	.00	.09	.46	.56	.11	.00	.50	.18	.57	.45	.00
	3	.44	.17	.11	.31	.27	.00	.17	.45	.00	.38	.45	.19
	4	.53	.15	.36	.29	.37	.24	.25	.57	.27	.75	.44	.47
	5	.00	.00	.00	.00	.14	.50	.00	.00	.00	*	.33	.00
	6	.65	.11	.00	.69	.63	.00	.00	.62	.00	.75	.82	.11
	7	.40	.12	.00	.53	.59	.00	.00	.46	*	.74	.61	.06

*no responses during pre-CS interval

Table 49: Experiment 2. Suppression ratios on the last day of extinction for Group E.

	Stimulus											
Subject	A	AX	X	AX	X	A	A	X	AX	A	X	AX
1	.50	.52	.62	.44	.91	.58	.64	.64	.36	.64	.45	.73
2	.55	.52	.53	.75	.43	.44	.92	.59	.80	.27	.41	.83
3	.21	.52	.33	.42	.59	.67	.35	.71	.86	.57	.45	.56
4	.43	.21	.68	.41	.55	.22	.27	.41	.54	.43	.69	.50
5	.64	.68	.61	.76	*	.85	.52	.59	.71	.54	.61	.88
6	.67	.35	.55	.59	.44	.17	.55	.45	.75	.67	.67	.11
7	.42	.51	.62	.53	.64	.54	.50	.58	.56	.43	.36	.67

*no responses during pre-CS interval

Table 50: Experiment 2. Suppression ratios during summation testing for Groups E and C.

		Stimulus					
Group	Subject	BX	B	BX	B	B	BX
E	1	.17	.29	.55	.67	.64	.67
	2	.00	.03	.64	.14	.69	.50
	3	.04	.00	.82	.43	.71	.60
	4	.05	.22	.57	.55	.50	.67
	5	.58	.47	.70	.53	.50	.67
	6	.00	.64	.25	.67	.36	.33
	7	.83	.44	.79	.33	.43	.75
C	1	.07	.06	.00	.38	.24	.56
	2	.00	.08	.00	.11	.64	.00
	3	.00	.63	.62	.65	.60	.61
	4	.07	.48	.53	.56	.73	.59
	5	.22	.32	.69	.81	.56	.62
	6	.00	.12	.15	.00	.00	.57
	7	.00	.00	.76	.00	.00	.72

Table 51: Experiment 2. Suppression ratios on Day 1 of retardation testing for Groups E and C.

		Stimulus			
Group	Subject	X	X	X	X
E	1	.52	.60	.62	.28
	2	.48	.05	.79	.00
	3	.47	*	.41	.70
	4	.59	.64	.57	.64
	5	.60	.80	.56	.53
	6	.64	.50	.42	.58
	7	.67	.57	.56	.57
C	1	.65	.06	.00	.00
	2	.47	.00	.00	.00
	3	.56	.00	.57	.00
	4	.41	.26	.42	.13
	5	.40	.31	.60	.00
	6	.58	.09	.38	.00
	7	.34	.05	.57	.00

*no responses during pre-CS interval

Table 52: Experiment 2. Suppression ratios on Day 2 of retardation testing for Groups E and C.

		Stimulus			
Group	Subject	X	X	X	X
E	1	.14	.00	.06	.40
	2	.11	.00	.00	.00
	3	.00	.00	.10	.25
	4	.00	.30	.00	.08
	5	.74	.53	.27	.68
	6	.38	.43	.38	.40
	7	.43	.50	.20	.52
C	1	.00	.00	.00	.00
	2	.00	.00	.00	.00
	3	.00	.00	.00	.00
	4	.04	.12	.00	.00
	5	.00	.44	.44	.00
	6	.00	.00	.00	.00
	7	.00	.00	.00	.00

Table 53: Experiment 3. Suppression ratios on the last day of simultaneous compound conditioned inhibition training for Groups C and F.

		Stimulus											
Group	Subject	AX	A	A	AX	AX	A	A	AX	A	AX	AX	A
C	1	.42	.18	.00	.48	.56	.00	.00	.50	.22	.64	.60	.11
	2	.47	.00	.00	.62	.45	.00	.00	.40	.00	.62	.52	.00
	3	.43	.67	*	.57	.67	.00	.00	.50	.00	.75	.67	.00
	4	.69	.12	.00	.45	.50	.00	.00	.67	.00	.69	.65	.00
	5	.52	.00	.12	.48	.59	.00	.09	.52	.00	.65	.43	.00
	6	.33	.08	.14	.48	.62	.20	.14	.62	.10	.56	.59	.00
	7	.60	.00	.00	.60	.67	.33	.40	.42	.25	.60	.55	.00
F	1	.45	.11	.00	.45	.60	.00	.00	.62	.00	.55	.53	.00
	2	.43	.07	.20	.35	.79	.15	.00	.81	.20	.88	.85	.25
	3	.25	.43	.33	.56	.78	.00	.00	.36	.22	.76	.39	.00
	4	.60	.00	.00	.56	.62	.00	.00	.77	.00	.83	.60	.00
	5	.00	.00	.00	.00	.00	.00	.00	.75	.00	.57	.38	.17
	6	.41	.10	.00	.50	.42	.12	.00	.60	.17	.67	.57	.17
	7	.79	.33	.06	.48	.48	.12	.09	.65	.11	.62	.50	.23
	8	.33	.00	.20	.75	.74	.14	.25	.64	.00	.76	.65	.00

*no responses during pre-CS interval

Table 54: Experiment 3. Suppression ratios during summation testing for Groups C and F.

Group	Subject	Stimulus AX	A	AX	A	A	AX
C	1	.52	.06	.43	.50	.59	.48
	2	.48	.00	.43	.60	.38	.45
	3	.00	.00	.38	.29	.73	.75
	4	.42	.00	.56	.00	.11	.40
	5	.24	.00	.45	.52	.46	.44
	6	.38	.00	.48	.00	.33	.59
	7	.00	.00	.50	.50	.80	.71
F	1	.00	.00	.30	.00	.17	.50
	2	.00	.00	.44	.64	.64	.20
	3	.00	.00	.53	.00	.36	.68
	4	.00	.00	.42	.25	.00	.47
	5	.00	.00	.44	.00	.00	.77
	6	.00	.00	.71	.57	.33	.53
	7	.00	.00	.57	.21	.30	.46
	8	.00	.00	.71	.25	.14	.71

Table 55: Experiment 4. Suppression ratios on the last day of simultaneous compound conditioned inhibition training for Group E.

		Stimulus											
Subgroup	Subject	AY	A	AX	AX	AY	A	AX	AY	A	A	AX	AY
E-L	1	.51	.18	.56	.43	.55	.17	.42	.55	.25	.00	.57	.93
	2	.89	.00	.40	.09	.25	.00	.50	.36	.00	.00	.33	.19
	3	.59	.46	.50	.55	.69	.17	.55	.71	.67	.50	.64	.75
	4	.43	.13	.53	.72	.64	.12	.47	.73	.00	.00	.72	.87
E-T	1	.55	.13	.53	.48	.44	.06	.52	.50	.08	.05	.60	.67
	2	.75	.27	.35	.47	.56	.44	.38	.61	.09	.20	.20	.65
	3	.53	.36	.53	.53	.50	.00	.44	.50	.09	.18	.40	*

*no responses in pre-CS interval

Table 56: Experiment 4. Suppression ratios on Probe and A (average of 2) trials on the 8 days of truly random training for Group E.

			Day							
Subgroup	Subject		1 AY	2 AX	3 AY	4 AX	5 AY	6 AX	7 AY	8 AX
E-L	1	A	.07	.07	.48	.24	.19	.47	.35	.23
		Probe	.00	.38	.71	.39	.39	.28	.63	.64
	2		.08	.00	.23	.00	.00	.38	.00	.11
			.15	.00	.71	.00	.61	.00	.70	.42
	3		.19	.06	.13	.37	.18	.40	.33	.34
			.51	.37	.62	.54	.60	.50	.59	.58
	4		.04	.07	.26	.09	.06	.00	.00	.08
			.65	.07	.59	.00	.59	.28	.81	.33
E-T	1		.04	.04	.08	.00	.16	.00	.06	**
			.58	.00	.63	.00	.69	.51	.70	**
	2		.14	.00	.16	.00	.00	.00	.33	.41
			.60	.00	.65	.36	.81	.50	.67	.31
	3		.45	.11	.37	.33	.35	.00	.37	.54
			.58	.34	.89	.43	.66	.63	.61	.70

**Data lost due to equipment failure

Table 57: Experiment 4. Suppression ratios on Probe and A (average of 2) trials on the 8 days of truly random training for Group N.

			Day							
Subgroup	Subject		1 AY	2 AX	3 AY	4 AX	5 AY	6 AX	7 AY	8 AX
N-L	1	A	.00	.00	.00	.18	.29	.19	.32	.00
		Probe	.00	.00	.00	.30	.00	.48	.00	.00
	2		.14	.00	.00	.21	.24	.00	.00	.09
			.00	.00	.00	.27	.56	.00	.70	.00
	3		.19	.06	.24	.33	.38	.00	.00	.31
			.00	.00	.17	.17	.00	.39	.30	.00
	4		.00	.00	.00	.00	.00	.18	.00	.14
			.00	.00	.00	.00	.28	.00	.37	.00
N-T	1		.00	.08	.15	.00	.10	.00	.00	**
			.27	.00	.26	.00	.00	.00	.58	**
	2		.25	.09	.31	.45	.34	.34	.39	**
			.54	.00	.61	.42	.47	.28	.67	**
	3		.00	.00	.19	.00	.00	.00	.07	.00
			.00	.00	.00	.00	.00	.00	.00	.00
	4		.02	.00	.03	.00	.00	.00	.09	.00
			.17	.00	.47	.00	.31	.00	.00	.00

**Data lost due to equipment failure

Table 58: Experiment 4. Suppression ratios during summation testing for Groups E and N.

Group	Subgroup	Subject	Stimulus AX	AY	A	AY	A	AX
E	E-L	1	.30	.55	.35	.79	.60	.61
		2	.00	.50	.00	.72	.14	.22
		3	.25	.47	.43	.54	.60	.63
		4	.06	.69	.00	.52	.00	.90
	E-T	1	.00	.67	.00	.87	.12	.38
		2	.00	.63	.00	.69	.00	.12
		3	.00	.62	.10	.41	.17	.42
N	N-L	1	.00	.14	.00	.00	.00	.00
		2	.00	.59	.00	.44	.36	.17
		3	.00	.22	.50	.57	.69	.18
		4	.00	.38	.14	.78	.00	.00
	N-T	1	.00	.39	.00	.79	.00	.00
		2	.06	.47	.50	.55	.27	.24
		3	.00	.00	.00	.00	.00	.00
		4	.00	.22	.07	.06	.00	.00